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AN INVESTIGATION INTO THE USE OF FACES AS A MEANS OF PRESENTING COST PERFORMANCE REPORT DATA

THESIS

Presented to the School of Systems and Logistics

of the Air Force Institute of Technology

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In Partial Fulfillment of the

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Captain, USAF

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The opinions and conclusions in this paper are those of the author and are not intended to represent the official position of the DOD, USAF, or any other government agency.

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I wish to thank all those who participated in the CPR FACES experiment. I know that the thought of using cartoon faces to help analyze cost performance data does not immediately appeal to everyone, but to those who are willing to try new ideas may come new successes.

I would like to thank my advisor, Captain Dave Christensen, for his support and insight. I hope his willingness to be creative and innovative brings him many rewards.

I would like to express deep gratitude to my wife Karyn. She had the tough job of putting up with me. She endured all my late nights, crazy schedules, and weird attitudes. Through all of it I can praise God more deeply for her love, her strength, and her companionship.

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Finally, I'd like to offer praise to my Lord Jesus Christ, who offers the path to true success (Joshua 1:8).

Jeffrey B. Tkach

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Abstract

This research focused on the use of faces as a means of representing contractor generated cost performance report (CPR) data. The study investigated the feasibility of using faces, and whether the use of faces would lead to effective decision making based on the information that the faces represent. The faces concept involves the transformation of data into cartoon-like faces by pairing specific variables of the data set with distinctive facial features, such as pupil location and nose length.

Feasibility of use was defined in terms of the availability of a personal computer based program that could be used to draw the faces and whether individuals would feel confident using the faces. Effective decision making is defined as the ability to make accurate decisions in a reasonable period of time.

A computer program was developed to draw the faces. A test scenario was designed to evaluate a user's decision making confidence and decision making effectiveness. The test utilized the tabular data presentation mode as a basis for comparison.

A statistical analysis of the data collected indicated that the use of faces resulted in lower decision making confidence and lower decision making effectiveness as compared to the use of tables. However, training and experience in the use of faces significantly increases both the confidence and effectiveness levels.

AN INVESTIGATION INTO THE USE OF FACES AS A MEANS OF PRESENTING COST PERFORMANCE REPORT DATA

I. Introduction

General Issue

The method of using cartoon faces to represent information (facial representation) may be useful in the analysis of Air Force contractor generated cost performance report (CPR) data. The use of cartoon faces to represent information was developed in 1973. The method employs a technique of matching certain facial characteristics with specific variables of the information set. The underlying strength of this method is that as the value of the variable changes, so does the shape of the facial characteristic. This allows the investigator to recognize relationships between the variables of the information set. The faces could be drawn by hand or by computer. Experiments have been done to determine whether this method would be beneficial in analyzing certain types of financial information. The results suggest that a beneficial potential does exist; however, additional research is recommended. To date, the Air Force has not accomplished any research in this area.

Specific Problem

The objective of this research is to determine if faces can be used for presenting and analyzing Air Force contractor generated cost performance data, and to determine if these faces can be used as an effective decision making tool.

Scope and Limitations

This study will compare the effectiveness of tabular and facial presentation in assisting a program manager in his/her evaluation of contractor cost performance data. Because no software previously existed to draw faces representing such data, this research has included the development of such software. After the software was developed, it was used to prepare a series of faces for comparison with tabular data.

Test subjects used in conducting the comparison experiment were limited to those individuals currently attending the Air Force of Technology (AFIT) in residence, specifically those in the Graduate Systems Management (GSM), Graduate Contracting Management (GCM), and Graduate Cost Analysis (GCA) Programs. A knowledge of cost performance measurement was not necessary, however, the population was limited to those who, because of their career fields, were familiar with its concept and will most likely be requiring cost performance measurement tools in the future.

The primary emphasis of the experiment is decision making effectiveness. Based on previous research in this area and in the area of graphical presentations in general, the following are considered to be the major variables of interest (5:4; 11:207):

Dependent Variables - decision accuracy and speed; and

Independent Variables - user background and mode of presentation.

Investigative Questions

The following questions were used to direct the focus of this research:

1) How can the method of facial representation be personal computer (PC) based? The answer to this question required an actual PC based software package.

2) An essential aspect of facial representation is the matching of variables to facial characteristics. It is necessary to determine what matches would be appropriate in the realm of Air Force contractor generated cost and performance data. Two questions that should be answered are:

a) What variables should be selected?

b) Which facial characteristics should be tied to each variable?

3) How effective is facial representation in conveying cost performance measurement data? For example, how useful is it as a decision making tool in decisions about contractor performance?

4) How does a person's level of experience impact the usefulness of the faces method?

The remainder of this study will be devoted to answering those four questions. Chapter II presents the findings of a review of the literature base pertaining to the use of faces as a means of representing information, especially financial information. This review will provide the reader with a general background in the history and use of facial representation. Chapter III presents a description of the methodology used to accomplish the research objectives. The methodology includes an experimental design to test a set research hypotheses.

Chapter IV follows with an analysis of experimental results. Chapter V summarizes the author's findings and presents recommendations for further study.

II. Literature Review

Overview

Facial representation of financial data is a method of analyzing and presenting financial information. It is not a well known method. Very little literature exists on the subject of facial representation. The author of this literature review could not find any literature dated after 1987 that specifically dealt with facial representation. Its use, however, may prove advantageous over some of the other analytical methods that are commonly employed to analyze financial data.

In this chapter, the author will present his findings on a review of the literature that pertains to facial representation. The justification for this research effort is provided, followed by a discussion of the literature. In the discussion, the author will describe facial representation, present its potential uses, address its good and bad points, and identify some experiments that have been done concerning its use.

Justification

The study of facial representation is worthwhile for several reasons. Financial data are being produced every day by countless numbers of sources. Business firms generate financial statements to describe the financial condition of their company. The government generates budgets and financial status reports. Government contractors generate cost performance data that they present to the government for review. Most of this data are multivariate. Multivariate data are information

represented by several variables, such as costs, profits, and budget variances. Multivariate data, however, are hard to analyze and display because conventional methods such as line graphs, bar charts, and tables are not capable of showing the relationships that may exist between variables. As a result, much information is not discovered because of this inefficiency. A graphic that can display multivariate data and show the relationships between the variables would prove advantageous over conventional methods. Facial representation has this ability to handle multivariate data (7:53; 8:18).

Facial representation has been used to analyze the financial condition of business firms. Because of its ability to handle multivariate data, facial representation may prove worthwhile in the analysis of contractor cost performance information. This is the focus of this research study.

Description

Facial representation was developed by Herman Chernoff in 1971 (11:205; 13:192). Since then, several others have done studies on the concept as well as conduct experiments concerning its use. Moriarity records Chernoff's description of facial representation as follows: "Briefly it consists of representing a point in k-dimensional space by a picture of a face whose characteristics are determined by the position of the point" (11:205). Huff, Mahajan, and Black describe it as an approach that:

> consists of representing a point in k-dimensional space as a cartoon of a face whose facial features (such as length of nose, curvature of mouth, size of eyes, etc.) corresponds to components of the point. (11:205)

Basically, facial representation is a graphic technique that matches specific information variables with facial features to form a cartoon face. Chernoff's graphical technique allows one to combine several variables into a picture of a face. The face that is produced allows the investigator to see how all the variables fit together (2:361).

Chernoff does not refer specifically to the possibility of applying his method to the analysis of financial information. The idea that his method could be used to analyze financial information is presented by others, notably Moriarity (11) and Stock and Watson (13). Chernoff's methods were developed to be used with any type of numerical multivariate data as a means of analyzing multivariate information accurately and quickly (3:548).

Chernoff chose to use faces because "People grow up studying and reacting to faces all the time" (1:363). Benbasat and Dexter suggest that different people view information in different ways. The way the information is presented could have a profound impact on how it is used (3:378-379). They use an idea from Mason and Mitroff to highlight their point:

> What is information for one type [of decision maker] will definitely not be information for another. Thus as designers of MIS [Management Information Systems], our job is not to get (or force) all types to conform to one, but to give each type the kind of information he is psychologically attuned to and will use most effectively. [Mason and Mitroff, 1973, p.478] (3:379)

The idea that the way information is presented influences the decisions made as a result of that data is also discussed by Robert Libby. He presents three basic options for improving decisions. The first option is to change the information. The second option consists of educating the person making the decision to change his/her way of

dealing with the information. The final option is to replace the decision maker with a model (8:101). Chernoff's technique is a combination of the first two options by changing the way information is presented and then re-educating the decision maker to view the information in light of these faces.

Using Facial Representation

The object of facial representation is to construct a face based on specific information. This is done by pairing certain variables with specific facial features. The initial challenge then is to determine which variable to match to a specific facial feature (2:548). Faces have an advantage over other methods of presentation because they are "sufficiently rich in detail to present a large number of variables" (7:206) and "quite a bit is known about the saliency of features of a face, holding out the hope that important financial variables can be matched with salient features in a schematic face" (11:206). The first step, therefore, in using facial representation is to determine which variables to match to specific facial characteristics. Huff, Mahajan, and Black state that "this task is basically one involving personal judgment and preference" (7:55).

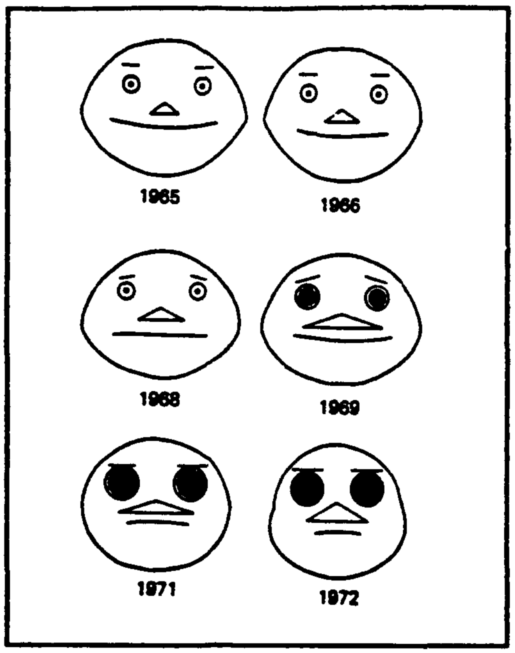
The second step for applying facial representation involves setting upper and lower boundaries for each financial variable and then setting a range for the facial feature (7:55).

The literature contains some general information on how to construct a face. The methods used to construct faces differ somewhat from user to user (7:54-55; 11:211-212). Figure 1 shows pictures of faces presented in the literature. Computer programs have also been developed

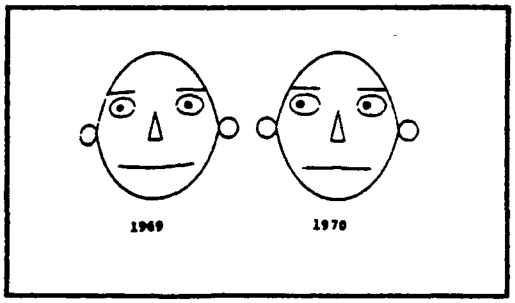
for the purpose of constructing faces. Huff, Mahajan, and Black describe a computer program that they employed in their studies, a modified version of a program reported in a paper by Bruckner (7:54). Moriarity also refers to the Bruckner program (11:212), as does Stock and Watson (13:197). Huff and Black also describe in detail a program code they developed along with the algorithms employed in developing that code (6). These programs were developed for use on a mainframe computer.

Why Use Facial Representation?

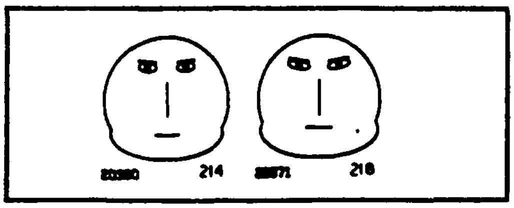
Before describing experiments that have been accomplished to determine the effectiveness of applying facial representation to financial information, it is appropriate to investigate further the advantages and disadvantages of using it. As mentioned previously, one primary rationale for using facial representation is its ability to present multivariate information. Because it can be used to present multivariate information, it allows the investigator to study several related variables at one time. As a graphical technique, it can help the investigator study the relationships between variables and identify any trends that may be developing between the variables (8:118; 11:205). A multivariate graphic helps the investigator see relationships between variables that are not detectable using a two-dimensional graphic. This is true because variables which have been previously shown on two



A. Moriarity and Roach (1977) - from Libby (8:119)



B. Moriarity (11:209)



C. Chernoff (1:364)

Figure 1. Examples of Faces in Literature.

separate graphics can be shown as one variable on a multivariate graphic. Then, as the value of one variable changes, the effect on the other variable is readily apparent (7:56).

Facial representation has several advantages over other multivariate graphic techniques. Its unique way of presentation is one specific advantage. Chernoff highlights the advantage as follows: "People grow up studying and reacting to faces all of the time. Small and barely measurable differences are easily detected and evoke emotional reactions from a long catalogue buried in the memory" (1:363). Facial expressions prompt an emotional response from humans. In addition, humans have the ability to detect even the slightest change in a facial expression. This acts as a big advantage when faces are used to portray financial information. When one looks at a face, he/she can easily pick out the major characteristics that are portrayed by that face. This ability enables that person to gain quickly an understanding of the information represented. After a more detailed study of the faces, that person would be able to pick out fine details and correlations that are present, and which were not apparent at first glance. This would be done in such manner that "The awareness of these [fine details and correlations] does not drive out of the mind the original major impressions" (2:364). Facial representation, therefore, enhances the investigator's ability to perceive the information and process it. Chernoff adds: "The major advantage to be derived from using the faces should be in the heightened qualitative awareness of which numerical calculations are relevant" (1:364).

Because people are familiar with faces, facial representation may help them understand information that they otherwise might not be able

to grasp. The manager who has trouble comprehending financial information as it is normally presented (tables, line graphs, etc.) may be able to relate to a series of faces representing that information, and as a result, gain an understanding of what that information is trying to express. With a better understanding of the information the manager will be able to make better decisions (11:206).

Another advantage facial representation offers is its ability to graph several variables at one time. Certain studies have shown that as many as 13 variables could be displayed on a single face (11:206). Table 1 lists variables employed in constructing a face along with the facial feature each variable has been matched with.

One other advantage in using facial representation to portray financial information that is worth mentioning is that the method is inexpensive and easy to use. The technology for drawing faces has already been developed. Computer programs have been developed for mainframe computers that will draw the faces, eliminating the hassle of drawing faces by hand (8:118).

One of facial representation's advantages is also one of its disadvantages. This is its uniqueness. Because the cartoon faces are also funny looking, it may be hard for people to take them seriously. This may diminish their effectiveness (8:120). Another potential disadvantage is that "the relative importance of certain variables may be exaggerated because of the facial features to which they have been assigned" (7:57-58). People may perceive the importance of certain

TABLE 1

List of Sample Financial Variable/Facial Feature Matches (7:56)

FINANCIAL VARIABLE	FACIAL FEATURE
Return on Assets	Curvature of mouth
Debt Service	Eccentricity of lower ellipse (face)
Cash flow	Eccentricity of eyes
Capitalization	Half-length of eyes
Current Ratio	Ear diameter
Cash turnover	Angle of eyebrow
Receivables turnover	Position of pupils
Inventory turnover	Length of eyebrow
Sales per dollar working capital	Eccentricity of upper ellipse (face)
Retained earnings/ total assets	Length of nose
Total assets	Width of nose

facial features differently. One person may assign more importance to the nose than the mouth, while another may assign more importance to the mouth than the nose.

Feasibility Studies

Much of the literature about facial representation of financial variables pertains to experiments that were conducted to determine the feasibility of using faces to portray financial information. In one such experiment, participants were to detect a change in the financial condition of a company (13:194). Another experiment had students analyzing companies to determine if they qualified as candidates for bankruptcy (11:206). The intent of both experiments was to determine

whether students could analyze the pertinent information more accurately and quickly with facial representation than without it.

The methodology used to conduct the above experiments was similar for both experiments. In each case, the researchers sought out people having varied levels of accounting experience. The experiments were conducted with groups of twenty to thirty people. The participants were given information on twenty to twenty-two different firms. The information for each firm was contained on one 8 1/2" by 11" sheet of paper. The information was presented with and without faces. Moriarity differed from Stock and Watson by presenting the faces with and without an explanation of what each facial feature represented. Stock and Watson did not include such an explanation. In both cases, a number was assigned to each of the firms. The collection of the financial information representing the firms was placed in 9" by 12" packets and then distributed. Instructions were given orally. The information in the packet also included a statement that "The firms included in your packet were determined randomly so that your answer may differ from that of your neighbor" (13:196). This statement was not true. All participants received the same firms. Participants received five minutes of instruction and were given 20 minutes to complete the study (11:207-213; 13:196).

The results of Moriarity's experiment are shown in Table 2. In his experiment participants analyzed the information more accurately and more quickly with the use of faces than without. In both cases this difference was significant at the 0.05 level. Moriarity used the data for both decision accuracy and decision speed to calculate a score for each condition. The score was equal to the percentage of correct

answers divided by the time to complete the task. This difference between scores also favored the faces mode and was significant at the 0.05 level. When the information was presented in the form of faces along with an explanation of what the faces represented, participants analyzed the information more accurately with the use of the faces with the explanation than with the use of faces without explanation, although this difference was not significant at the 0.05 level. The use of faces without explanation was quicker than the use of faces with explanation. This difference was significant at the 0.05 level. The difference in score also favored the use of faces without explanation. This difference was significant at the 0.05 level (11:213-218).

In Stock and Watson's experiment, participants were also more accurate in their analysis when faces were used. The results of their experiment are also shown in Table 2. The difference in accuracy was significant at the 0.05 level. This difference did not vary significantly based on the level of the participant's accounting knowledge (13:198). Stock and Watson also tested decision times. Their findings in this area did not support Moriarity's findings in that the difference in decision times between the two modes was not significant (13:199).

Moriarity drew this conclusion from his experiment:

> While the evidence from the experiment suggests that schematic faces are an efficient means of communicating financial information, there are several areas related to their construction and use which need further research. (13:222)

These additional areas of research include investigating different financial characteristics, changing the financial variable/facial feature pairings, and examining the effect of training with the faces to

determine whether it might be less expensive to train people in the use of faces as opposed to other techniques (13:222-223).

Stock and Watson report their conclusions based on human judgment accuracy. "The results indicate that human judgement accuracy can be influenced by the report format used for displaying accounting information" (13:200). They also consider that "The implication of these results is that accountants might consider changing or augmenting the format for displaying accounting information as one option for improving human judgment accuracy" (13:200).

A third experiment was performed after Moriarity and Stock and Watson. Mackay and Villarreal (MV) set out to test the validity of Moriarity's and Stock and Watson's findings. Their research focused on three main issues:

1. "The validity of the conclusion that faces do better than tabular displays" (9:536),

2. "The identification of situations where one display procedure may be expected to be superior to the other" (9:537), and

3. "The role of individual differences in determining the relative success of using facial or tabular displays" (9:537).

The basis for their argument in issue one was that participants in Moriarity's experiment had very little understanding of what the financial ratios represented. MV believed that in order to obtain a more meaningful comparison participants should have had some experience working with the financial ratios and that the ratios should have been defined carefully.

TABLE 2

Summary of Experiment Results

A. Moriarity (1979)

Mode Of Presentation			
Participants	Faces without Explanation	Faces With Explanation	Ratios
Students			
Average Errors	7.313	7.092	8.620
Average Time (sec)	218.88	371.88	480.96
Score *	11.617	6.814	5.211
Experts			
Average Errors	5.75	6.20	7.40
Average Time (sec)	280.08	376.92	344.88
Score	9.652	7.185	7.056

* Score = percent correct/time (in hours)

B. Stock and Watson (1984)

Percent Correct Answers		
Level Of Experience	Using Faces*	Using Ratios
Elementary	51.32	47.35
Intermediate I	50.00	45.60
Intermediate II	50.68	45.08
Experts	52.38	42.85
Overall	50.70	45.67

* Faces provided without explanation.

MV's concern in issue two is that both experiments (Moriarity and Stock and Watson) focused on determining which was the better method, faces or ratios. The focus, they believed, should be on determining the situations where one method outperforms the other. This could be done by "looking at the qualities attributed to graphic and tabular methods and then considering circumstances where these qualities might make a difference" (9:537).

MV's third issue suggests that the field of psychological literature that deals with the responses of subjects to facial displays should be examined and applied to the area of representing financial data with faces. MV states that "one of the primary conclusions of this literature is that individuals do differ in their responsiveness to facial cues" (9:537).

To address his issues MV also conducted an experiment in which he had participants evaluate whether a particular firm was a candidate for bankruptcy. Participants were shown financial data in both display modes, faces and ratios. The financial data were obtained from different firms, half of which had file for bankruptcy. MV used a sample of 98 MBA students, most of which had prior work experience in the use of ratios (9:538-539).

MV's results did not support those obtained by Moriarity and Stock and Watson. The difference in the amount of correct answers favored the faces mode (difference in mean scores was 0.23), however this difference was not significant. MV's results did support Moriarity's results in that the use of faces resulted in faster decision times. These results supported MV's premise in his first issue, that the lack of experience in using ratios had an impact on the favoritism that the faces mode

experienced in the previous experiments. MV compensated for this lack of experience, and as a result the faces mode was not as favored (9:540-541).

The results of MV's experience also supported their arguments in their other two issues. In addressing the second issue, MV found that the ratios did a better job predicting bankruptcy while the faces did a better job predicting successful firms. In both cases, the differences were significant. In addressing the third issue, MV investigated individual differences in responses to both modes of presentation. The only significant variable that appeared was gender. Women were found to process facial cues more successfully than men (9:541-544).

Summary

Face analysis may be an effective tool for analyzing financial information. Face analysis offers several advantages over other techniques. Its ability to handle multivariate data allows the investigator to see the relationship and trends occurring among several variables. The familiarity that people have with faces makes it an effective analytical tool for those individuals not familiar with financial reporting concepts.

Face analysis does have disadvantages. Because of its use of cartoon faces, some people may not take it seriously. The possibility that some people may misinterpret the significance of some of the financial variable/facial feature pairings may also decrease its effectiveness.

Experiments have been conducted that show that the use of faces in analyzing financial data is more effective than some of the common analytical means. The results of these experiments were similar for

people with little knowledge pertaining to the analysis of financial data and for people with much knowledge in this area.

The conclusion that the literature presents is that facial representation may be a good tool for analyzing and presenting financial data. Additional research involving facial representation of financial information is encouraged.

III. Methodology

The primary method that was employed in the execution of this research study is experimentation.

Justification of Experimental Approach

Up to this point, facial representation has never been used to portray and analyze Air Force contractor cost performance data. Sufficient data do not exist that can be used to determine whether facial representation is an effective decision making tool when applied to such data. Therefore, this data must be produced. Experimentation is an effective means of producing this data. It can be done within the time limitations placed on this research study. It also allows the investigator to control the independent variables, user background and mode of presentation, described in Chapter I.

Task to be Accomplished

As described through the use of the investigative questions in Chapter I, the task to be accomplished was composed of four major areas:

1. Obtaining or developing a PC-based computer program for drawing the faces,

2. Selecting CPR variables to be analyzed and matching those variables to facial features,

3. Determining the usefulness and effectiveness of facial representation as a decision making tool, and

4. Determining whether a person's level of experience has an impact on the usefulness of the faces method.

Upon initial evaluation of experimental results, a fifth task area was added:

5. Determining the impact of both learning and training on the effectiveness of the faces method.

Task areas three through five were accomplished through experimentation and survey. Task areas one and two had to be accomplished first in order for the experiment to be developed. The remainder of this chapter describes the methods used to accomplish the above tasks.

Computer Program Development

Before the experiment was developed, a computer program able to draw the faces and that is also PC-based had to be obtained or written. The program had to be PC-based rather than mainframe-based for two reasons. First, one intent of this research study is the development of the faces concept for use as a tool in Air Force cost performance measurement. For it to be used extensively as a tool, it needs to be inexpensive and obtainable. A PC-based program satisfies those requirements. Second, a PC-based program was required to conduct the research experiments. A PC-based program significantly aids in data entry, data selection, and data analysis. The investigator conducted a search to determine whether a PC based computer program already exists. To date no such PC-based program has been discovered, although not all avenues have been searched. The investigator had obtained a written code for a program that is not PC-based (6). A few other programs were also available for mainframe-based computers. Because a PC-based program does not exist, the investigator developed one using MicroSoft QuickBasic (10).

Appendix A contains a description of this program, called CPR FACES. The computer code for CPR FACES is also provided in Appendix A.

Variable Selection/Facial Feature Pairing

Once the program was developed, the investigator paired contractor cost performance data variables to appropriate facial characteristics. Since the choice of pairings is basically a function of "personal judgment and preference" (7:55) the actual pairings may not represent the optimal pairing possible. A study of the effects of different cost performance variable/facial characteristic pairings will be left for possible future research. This information was put into the computer program.

Research Hypotheses

As mentioned previously, task areas three through five were accomplished through experimentation and survey. This section describes the hypotheses that were used in this study to accomplish those task areas. The following section describes the experiment and survey used to test the hypotheses.

Effectiveness/Usefulness Hypotheses. To determine the degree of decision making effectiveness that can be achieved when faces are used to analyze CPR data, several hypothesis were developed. Decision making effectiveness is a function of both decision speed and decision accuracy. A separate hypothesis was developed to test both of these factors. A third hypothesis was designed to test specifically for decision making effectiveness. This hypothesis utilizes the data obtained from testing the first two hypotheses, that of decision speed

and decision accuracy. A fourth hypothesis deals with a specific area of decision making effectiveness, the analysis of trends. To determine a degree of usefulness, one primary factor was considered, decision making confidence. The assumption behind this hypothesis was that individuals would not use a specific decision making tool if they were not confident making decisions when using that tool. The hypotheses are listed below:

1. Individuals will take less time evaluating data in the faces format than they will evaluating data in the tabular format.

2. Individuals will be more accurate evaluating data in the faces format than they will evaluating data in the tabular format.

3. Individuals will be more effective making decisions when evaluating data in the faces format than they will evaluating data in the tabular format.

4. When attempting to evaluate trends in data, individuals will be more effective when using the faces format than they will using the tabular format.

5. Individuals will feel as confident using the faces presentation mode as they will using the tabular presentation mode.

Impact of Experience Level on Decision Making Effectiveness

Hypothesis. One hypothesis was created to determine the impact that an individual's experience level in the analysis of CPR data had on decision making effectiveness. The hypothesis is:

6. Individuals without experience in analyzing cost performance data will score the same on decision making effectiveness when analyzing face data as those individuals with cost performance report experience.

<u>Impact of Learning and Training Hypotheses</u>. The next hypothesis was developed after initial evaluation of experimental results. The investigator noted that decision making effectiveness scores on the second half of the experiment appeared to be greater than on the first half of the experiment. The hypothesis was used to test if learning was occurring during the experiment.

> 7. During the experiment learning occurred in such a way that decision making effectiveness was greater in the bottom half of the experiment.

The above hypothesis led to the development of further hypotheses that were used to determine whether training participants in the use of faces would result in greater decision making effectiveness and greater usefulness, (again, using decision making confidence as a factor for measuring usefulness). To test for the impact of training on decision making effectiveness and usefulness five hypotheses were tested in this study. The instruction mentioned in these hypotheses refers to five minutes of oral teaching that was given to experiment participants to instruct them on how the faces should be interpreted. The hypotheses that were tested are:

> 8. Individuals who received a five minute instruction on the use of faces will answer the faces related questions faster than those who did not receive the instruction.
>
> 9. Individuals who received a five minute instruction on the use of faces will answer the faces related questions more accurately than those who did not receive the instruction.
>
> 10. Individuals who received a five minute instruction on the use of faces will score higher in decision making effectiveness when answering the faces related questions than those who did not receive the instruction.

11. Individuals who received a five minute instruction on the use of faces will be more confident making decisions using faces than those who did not receive the instruction.

12. Individuals who received the five minute instruction on the use of faces will more likely to use the faces format in their jobs, if given the opportunity, than those who did not receive the instruction.

Experiment Construction

Ideas for the experiment framework were obtained from experiments by Moriarity (2:207-213), Stock and Watson (13:194-199) and Grigware (5:16-25). The focus of interest is contractor cost performance data. Contractor performance data were fabricated for eight fictitious contracts. Participants were provided cost performance report data for each of these contracts in one of two ways:

1. Tabular Form listing Budgeted Cost of Work Scheduled (BCWS), Budgeted Cost of Work Performed (BCWP), Actual Cost of Work Performed (ACWP), Schedule Variance, and Cost Variance; or

2. Facial Representation - A set of faces representing contractor performance.

Each participant received four sets of data using the tabular form and four sets of data using faces. The data sets were randomly distributed such that while each participant received the same eight contracts, the distribution of the presentation modes of the sets were different.

A QuickBASIC program was developed for the experiment. A description of the program is provided in Appendix B. The experiment was done on computer instead of using paper handouts to add validity to the experiment. Since the CPR faces concept is intended to be a computer

based tool, a computer based experiment will provide more realistic scenarios. The experiment program consisted of four main areas. The first program area consisted of an introduction screen, which included a narrative about the experiment. The second area was designed to ask the participant a few background questions such as Air Force Specialty Code (AFSC) and experience. This information was used to characterize participants by background, allowing the investigator to determine the impact of user background on experimental results. In the third area, the participant was shown a screen with three faces and three corresponding tabular data sets. One data set and face depicted neutral contract performance (contract on cost and on schedule). Another data set and face depicted very good contract performance (well ahead of schedule and well under cost). The third data set depicted very bad contract performance (well behind schedule and well under cost). The last eight screens comprised the fourth area. This area was the main experiment section. In this area, participants were shown cost performance measurement data in the form of faces and in tabular form. They were also asked questions related to the data on the screen.

Experiment Design. Each of the eight screens in the fourth area were designed to represent the performance of one contract. Four CPR data sets were generated for each screen; these four data sets will be called a contract data group. Thirty-two data sets were generated for the experiment, or a total of eight contract data groups. Four of the contract data groups included information for three sub-elements of the contract and information for overall contract performance. These contract data groups were designed to test the participant's ability to

analyze actual contract performance. The other four contract data groups included information for the overall performance of the contract over four periods of time. These contract data groups were designed to test the participant's ability in analyzing trends in contract performance.

The eight contract data groups were then assembled by generating eight different combinations of the groups. Each overall experiment data set (consisting of all eight data groups) was copied to a floppy disk containing the experiment program. Thirty-two floppy disks were used. Each overall data set was included on four floppy disks. The thirty-two disks were randomly sorted and distributed. As a result, all participants were shown four groups of CPR data in the form of faces and four sets in the form of tables. All eight contract data groups were shown to each participant; however, the program was designed such that while one person saw a particular group in the form of faces, another person would see the same group in the form of tables. This way, each participant had the opportunity to use both faces and tables.

The contract data groups were also distributed to act us a control on itself. Since each group was shown using both faces and tables, no group had an advantage over another. The contract data groups were also distributed such that a particular group might appear at any stage in the experiment. One person would see contract data group 1, for instance, in the first of the eight screens. Another might see contractdata group 1 in screen five. Appendix C provides a listing of the data used for the experiment. Appendix D shows the experiment test scenario.

Experiment Questions. For each contract data group designed to test participant's ability to analyze contract performance, participants were asked four questions to test their ability to draw information and make decisions from the data. The questions are:

1) Is the contractor behind or ahead of schedule?

2) Is the contractor over or under cost?

3) What elements (from the three sub-elements) are over cost?

4) What elements are behind schedule?

For each contract data set designed to test the participant's ability to analyze trends in contract performance, the following two questions were asked:

1) What is the trend in cost performance (getting better, getting worse, or no trend)?

2) What is the trend in schedule performance (getting better, getting worse, or no trend)?

The experiment program was designed to record the time that the participant took on each screen. This was devised to record the amount of time it took each participant to analyze the data and answer questions based on that data. This information was recorded in order to determine a measure of decision making effectiveness, calculated using both the number of correct answers and the time needed to answer questions.

Experiment Administration

The experiment was administrated to groups of 2 to 12 people. The group received five minutes of oral explanation and instructions dealing with the actual operation of the experiment program. Each participant was given an information sheet listing some key definitions as well as

the facial feature, cost performance pairings used in the faces program (Figure 2), and another sheet that was exactly the same as the computer screen mentioned previously which list faces and data sets depicting good, bad, and neutral performance (Figure 3).

Population. Participants were selected from current AFIT graduate programs. The investigator had hoped to include students from AFIT Professional Continuing Education (PCE) courses; however, due to the amount of time it took to construct the program and the difficulty of scheduling computer rooms with PCE times, this was not possible. The experiment requires that each participant have at least a general knowledge of cost performance measurement to the extent that they were at least familiar with the term. To accomplish this, participants were limited to the following groups:

1. AFIT students in either the Graduate Systems Management (GSM) program, the Graduate Contracting Management (GCM) program, and the Graduate Cost Analysis (GCA) program.

2. AFIT PCE students attending cost performance measurement related courses. Again, due to the above constraints, this was not possible.

Experiments were conducted in groups of 2 to 12 participants. This size was limited due to the number of available computers. Because it was more feasible to choose classes or groups that were already formed, the sample was not random. Each member of the population did not have an equal, non-zero chance of being selected.

Information Sheet

The following information may prove helpful when answering the questions. Please take a few moments to look over this sheet before starting and refer back to this sheet if necessary during the experiment:

DEFINITIONS:

BCWS - Budgeted Cost of Work Scheduled - the amount of work that should have been completed to date and the amount it should have cost.

BCWP - Budgeted Cost of Work Performed - the amount of work that has actually been completed and the amount that work should have cost.

ACWP - Actual Cost of Work Performed - the actual cost of the work that has been completed.

COST VARIANCE = BCWP - ACWP   If positive, contractor is under cost

SCHEDULE VARIANCE = BCWP - BCWS If positive, contractor is ahead of schedule

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The following facial characteristic - cost performance variables are represented:

Cost Variance - eyebrow position

Schedule Variance - pupil position

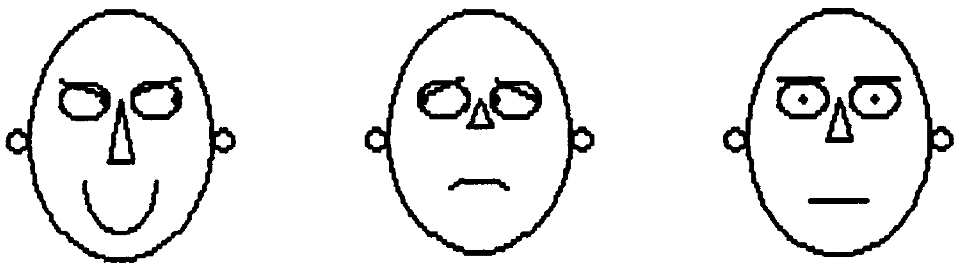
Cost Performance Index - measure of cost performance equal to BCWP/ACWP - curvature of the mouth

Schedule Performance Index - measure of schedule performance equal to BCWP/BCWS - nose length

TCPI - "To Completion Performance Index" - measure of ability to complete work on schedule - shape of face

The following screen (after the information screen) provides some sample faces with accompanying tabular data.

Figure 2 - Information Sheet



GOOD BAD NEUTRAL

Cost Performance Information

BCWS	2000	10000	4000
BCWP	4000	4000	4000
ACWP	2000	7000	4000
BAC	15000	15000	15000

Figure 3 - Examples of Faces

Criteria for Analysis

The results of the analysis using these two methods of presentation will be compared to the actual performance that the data represents. This comparison was used to compute a measure of effectiveness in decision making using facial representation versus that of using the data presented in tabular form. Effectiveness will be defined as accuracy of decision (number of questions answered correctly) per unit time taken to make that decision (in minutes).

Tests for Decision Making Effectiveness. Hypotheses one through four were tested using data obtained from the above experiment questions. Decision speed was based on the amount of time taken to complete a particular question set. Decision accuracy was based on the number of correct answers achieved. Decision making effectiveness scores were based on both decision speed and decision accuracy. Hypothesis four, dealing with trend determination, was based only on those questions pertaining to the analysis of trends.

Tests for Decision Making Confidence. At the end of the computerized experiment, participants were given an eight statement survey (Figure 4) designed to measure the following factors.

1. The confidence that the participant had in making decisions using data presented in the form of faces and in tabular form (statements one and two);

2. The perception of the participant of the accuracy of both modes of presentation (statements three and four);

3. The perception of the participant of the ease in understanding information when presented in the form of faces and in tabular form (statements five and six);

4. The perception of the participant on whether or not he /she felt that he/she answered more questions correctly using the faces format (statement seven); and,

5. Whether or not the participant would use the faces format in a job experience if he/she had opportunity to do so (statement eight).

The survey used a five point Likert scale to measure responses to the survey statement. A response of five indicated that the person strongly agreed with the statement, a response of one indicated that the participant strongly disagreed with the statement.

Hypothesis five was tested using the mean number of answers to parts one, two and three above for the faces format (survey questions one, three, and five) and the mean number of answers to parts one, two, and three for the tabular format (survey questions two, four, and six.

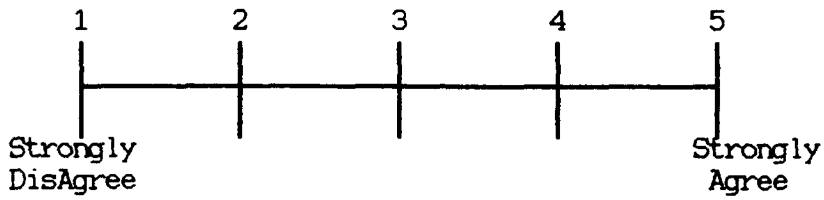
The answers to part four (survey question seven) were added up to obtain a mean value. This value gives an indication as to whether participants felt they made good decisions using faces as compared to the decisions they made using tables. A mean value of 3.0 would indicate that they felt that decisions made with faces were as good as those made with tables.

The answers to part five (survey question eight) were added up to obtain a mean value. This value gives an indication as to whether participants would use the faces format in their own work if given the opportunity. A mean value of 3.0 would indicate that half of the participants would probably use the faces if given the chance.

Parts four and five were not meant to provide a statistical basis for the usefulness of the faces format. They were meant to ascertain if people felt comfortable with the use of faces and whether the might actually use faces in their work. Mean values of three or greater in these areas indicate that people feel comfortable enough with the use of faces that further research into the application of faces is warranted.

Faces Experiment Survey   Disk No. _______

Use the scale below to answer the following questions:



_____1. I felt very confident answering the experiment questions when the data was presented in the form of faces.

_____2. I felt very confident answering the experiment questions when the data was presented in tabular form.

_____3. The faces format is very accurate.

_____4. The tabular format is very accurate.

_____5. The faces format was easy to understand.

_____6. The tabular format was easy to understand.

_____7. I did better answering questions (got more correct answers) using faces data than I did using tabular data.

_____8. If I had the opportunity I would use the faces format in my job.

Figure 4 - Faces Experiment Survey

Test for Impact of Experience Levels. The tests for decision making effectiveness were redone to determine the impact that experience levels have on the experimental results. In this case, the experimental data were divided based on the experience levels (experience using cost performance measurement) of the participants. The data were used to test hypothesis six to determine if the above results hold at different experience levels.

Tests for Impact of Learning and Teaching. As previously mentioned, upon analysis of the experiment data from the first thirty samples, it became evident that learning was occurring. As the experiment progressed (from screen one to screen eight) participants were answering questions faster (although with similar accuracy). Hypothesis eight was used to determine if learning did occur. The experiment data was divided into halves, with the data from the first half compared against data from the second half. Based on these initial results, the investigator modified the experiment by giving the participants a five minute lecture in the use of faces, as well as modifying the handout with the sample faces by including an explanation of how each variable/facial characteristic pair operates. The investigator then tested hypotheses eight through twelve.

Statistical Analysis

All hypotheses were tested using either a paired t test or the Wilcoxon Sign-Rank Test. All tests were done using the STATISTIX SOFTWARE PACKAGE (12). The type of test used depended upon the distribution of the data to be tested. A Wilk-Shapiro test for normality was used to determine whether the data were normally

distributed. If the test indicated a normal distribution, the parametric paired t-test was used. If the data failed the test for normality, the distribution free, Wilcoxon Sign-Rank test was used. All tests were conducted using a level of significance of 0.05. (4:290-307, 598-607)

IV. Analysis and Results

Overview

The purpose of this study is to determine whether the faces method of representing cost performance information is a viable tool for analyzing such data. The main concern of the study is: Does the use of faces result in effective decision making? Effectiveness is defined in terms of decision accuracy and speed. Confidence in making the decision is also considered a critical factor.

In order to analyze the effectiveness of the faces method, an experiment was performed comparing the faces method to a common form of cost performance data presentation, tables. Several research hypotheses were formed to measure the effectiveness of the faces method. These research hypotheses were tested by means of experimentation and survey. This chapter presents an analysis of the results that were obtained.

Several additional hypotheses were formed during the operation of the experiment. The premise of these hypotheses is that both learning and training play an important role and that both will result in more effective and more confident decisions. These hypotheses were also tested and the analysis of those test results are also included in this chapter.

In order to be consistent with the format used in the statistical tests, each hypothesis has been restated in terms of a null and alternate hypothesis.

Population

Fifty individuals, 48 military and 2 civilians, participated in the experiments of this research study. Thirty individuals, all military, participated in the first part of the study. The remaining twenty participated in the second part. The average individual was a an Air Force captain, with a 2724 Air Force Specialty Code (AFSC), having four years experience with the 2724 AFSC, and less than one year of C\SCSC experience. Table 3 shows breakdown of experiment participants by AFSC, rank, years of experience with current AFSC and with using C/SCSC.

The population statistics show that most of the individuals involved in the experiments have been involved in acquisition related activities in the Air Force. These individuals are involved in acquisition related graduate programs and they will eventually have the responsibility of evaluating contractor cost performance information in the jobs. These qualifications make them excellent subjects for evaluating methods of cost performance data presentation, especially those methods that can be used to make decisions about contractor performance.

Analysis Overview

Effectiveness in decision making is defined in this study as a function of both decision accuracy and decision speed. In this analysis, both decision accuracy and decision speed were first evaluated separately, and then evaluated as a measure of decision making effectiveness. Another important factor, decision making confidence, was also evaluated. Decision makers place their reputations at risk,

TABLE 3

Population Statistics

	COUNT		
A. RANK	Experiment 1	Experiment 2	Total
First Lieutenant	0 / 0.0%	5 / 25.0%	5 / 10.0%
Captain	28 / 93.3%	13 / 65.0%	41 / 82.0%
Major	2 / 6.7%	0 / 0.0%	2 / 4.0%
GS-12	0 / 0.0%	1 / 5.0%	1 / 2.0%
GM-13	0 / 0.0%	1 / 5.0%	1 / 2.0%
Total	30 /100.0%	20 /100.0%	50 /100.0%
B. AFSC			
27XX	21 / 70.0%	9 / 45.0%	30 / 60.0%
28XX	5 / 16.7%	2 / 10.0%	7 / 14.0%
65XX	1 / 3.3%	1 / 5.0%	2 / 4.0%
67XX	3 / 10.0%	6 / 30.0%	9 / 18.0%
1102	0 / 0.0%	1 / 5.0%	1 / 2.0%
1515	0 / 0.0%	1 / 5.0%	1 / 2.0%
Total	30 /100.0%	20 /100.0%	50 /100.0%
C. Years Experience in AFSC			
< 2.0	4 / 13.3%	2 / 10.0%	6 / 12.0%
2.0 - 4.0	5 / 16.7%	8 / 40.0%	13 / 26.0%
4.1 - 6.0	20 / 66.7%	10 / 50.0%	30 / 60.0%
> 6.0	1 / 3.3%	0 / 0.0%	1 / 2.0%
Total	30 /100.0%	20 /100.0%	50 /100.0%
D. Years C/SCSC Experience			
None	19 / 63.3%	12 / 60.0%	31 / 62.0%
< 1.0	2 / 6.7%	1 / 5.0%	3 / 6.0%
1.0 - 2.0	5 / 16.6%	5 / 25.0%	10 / 20.0%
2.1 - 4.0	2 / 6.7%	2 / 10.0%	4 / 8.0%
> 4.0	2 / 6.7%	0 / 0.0%	2 / 4.0%
Total	30 /100.0%	20 /100.0%	50 /100.0%

and sometimes their jobs, whenever they make a decision. It is important that they are confident with the decisions that they make. It is also important to the United States Air Force, because of the great amount of money involved in each contract, that each of its decision makers is making confident decisions. Decision making confidence will be evaluated as a function of the decision maker's perceived confidence, the decision maker's perception of the decision making tool as being accurate, and the decision maker's ability to understand the information used to make the decision.

Finally, in order for a decision making tool to be worthwhile, individuals must be willing to use it. This analysis will examine whether individuals will utilize the faces format in their decision making if given the opportunity.

Test for Decision Speed - Hypothesis One

NULL HYPOTHESIS: Individuals will take the same amount of time evaluating data in the faces format as they will evaluating data in the tabular format.

ALTERNATE HYPOTHESIS: Individuals will take less time evaluating data in the faces format than they will evaluating data in the tabular format.

The experiment computer program enabled each participant to be timed for each question set. One question set was included for each of the eight data sets that the individual encountered during the experiment. Four of the data sets involved data presented in the form of faces; the other four data sets involved data presented in tabular form. The time for each question set was recorded in seconds. The mean time required to answer questions using the faces format was 369 seconds. The mean

time required to answer questions using the faces format was only 210 seconds. This information is summarized in Table 4.

A one-sided paired t test was conducted to test the hypotheses. The test was performed using the STATISTIX software package. Both populations were normally distributed and it is assumed that the population variances are similar. To test for normality, the Wilk-Shapiro test for normality was used. The Wilk-Shapiro test for normality was used on all data distributions in this study. The difference in decision speed was not sufficient at the 0.05 significance level to reject the null hypothesis. The results of the test are summarized in Table 5. The results indicate that the faces format did not contribute to faster decisions. In fact, it is clear that tables took significantly less time.

TABLE 4

Time to Answer Questions

(Time in seconds)

MODE	MEAN	STANDARD DEVIATION	COUNT	MINIMUM	MAXIMUM
Faces	368.7	111.0	30	138.0	566.0
Tables	209.7	60.10	30	110.0	422.0

TABLE 5

Paired t Test - Time by Presentation Mode

PAIRED T TEST FOR Face Times - Table Times

MEAN	158.9	STD ERROR	17.49
T	9.09		
DF	29		
P	0.0000		

CASES INCLUDED 30 MISSING CASES 0

DECISION RULE: REJECT THE NULL HYPOTHESIS IF T < 1.699

Test for Decision Accuracy - Hypothesis Two

NULL HYPOTHESIS: Individuals will be as accurate (in terms of correct answers) evaluating data in the faces format as they will evaluating data in the tabular format.

ALTERNATE HYPOTHESIS: Individuals will be more accurate evaluating data in the faces format than they will evaluating data in the tabular format.

Individuals were asked a total of 24 questions in the experiment. Half of the questions involved data presented in the form of faces and the other half involved data presented in tabular form. The mean number of correct answers for face format questions was 7.7 and the mean number of correct answers for tabular format questions was 10.17. The data are summarized in Table 6.

To test the hypotheses, a one-sided paired t test was used. The results of the test are shown in Table 7. The difference in correct answers achieved for each mode was not sufficient at the 0.05 significance level. The null hypothesis was not rejected. The results indicate that the use of faces did not result in more accurate

decisions. Again, it is clear that more correct answers resulted from tabular data.

TABLE 6

Correct Answers

(Out of 12)

MODE	MEAN	STANDARD DEVIATION	COUNT	MINIMUM	MAXIMUM
FACES	7.667	1.647	30	4.000	11.00
TABLES	10.170	9.129E-01	30	8.000	12.00

TABLE 7

Paired t Test - Correct Answers by Presentation Mode

PAIRED T TEST FOR Face Answers - Table Answers

MEAN	-2.500	STD ERROR	3.482E-01
T	-7.18		
DF	29		
P	0.0000		

CASES INCLUDED 30 MISSING CASES 0

DECISION RULE - REJECT THE NULL HYPOTHESIS IF T > 1.699

Test for Decision Making Effectiveness - Hypothesis Three

NULL HYPOTHESIS: Individuals will be as effective making decisions when evaluating data in the faces format as they will evaluating data in the tabular format.

ALTERNATE HYPOTHESIS: Individuals will be more effective making decisions when evaluating data in the faces format than they will evaluating data in the tabular format.

For this study, decision effectiveness has been defined as a function of both decision speed and decision accuracy. Decision effectiveness is equal to decision accuracy divided by decision speed (in hours).

The mean value for decision effectiveness when the faces format is used is 84.05 correct answers per hour. The mean value for decision effectiveness when the tabular format is used is 188.10 correct answers per hour. The results are summarized in Table 8.

The paired t test could not be used in this case because the face format decision effectiveness data distribution failed the Wilk-Shapiro test for normality. The hypotheses were tested with the Wilcoxon Signed-Rank Test. Again, a one-sided test was used. The difference was not significant at the 0.05 significance level to reject the null hypothesis. The results indicate that the use of faces do not lead to more effective decisions. The results of the Wilcoxon Signed-Rank Test are shown in Table 9.

TABLE 8

Decision Effectiveness

MODE	MEAN	STANDARD DEVIATION	COUNT	MINIMUM	MAXIMUM
FACES	84.05	39.24	30	31.65	216.4
TABLES	188.10	57.37	30	85.31	360.0

TABLE 9

Sign-Rank Test - Decision Effectiveness

WILCOXON'S SIGNED RANK TEST FOR Face Effectiveness - Table Effectiveness

SUM OF NEGATIVE RANKS	-465.0
SUM OF POSITIVE RANKS	0.000
NORMAL APPROXIMATION WITH CONTINUITY CORRECTION	-4.772
TWO TAILED P VALUE FOR NORMAL APPROXIMATION	0.0000

TOTAL NUMBER OF VALUES WHICH WERE TIED 0
NUMBER OF ZERO DIFFERENCES DROPPED 0
MAX. DIFF. ALLOWED BETWEEN TIES 1.00E-05

CASES INCLUDED 30 MISSING CASES 0

DECISION RULE: REJECT THE NULL HYPOTHESIS IF NORMAL APPROXIMATION > 1.645

Test for Decision Making Effectiveness in Trend Determination -

Hypothesis Four

NULL HYPOTHESIS: The mode of presentation (faces or tables) will not affect the individuals ability (decision making effectiveness) to detect trends.

ALTERNATE HYPOTHESIS: When attempting to evaluate trends in data, individuals will be more effective when using the faces format than they will using the tabular format.

Graphical methods have been used effectively to aid the decision maker in the detection of trends in data. A few of the questions in the experiment were designed to measure the participants ability to detect trends in the cost performance data.

Table 10 shows the results from the trend detection questions. Based on the mean results, tables resulted in faster, more accurate, and more effective decisions. To test the hypotheses, the Wilcoxon Sign-Rank tests in STATISTIX was used. The data were not sufficient at the 0.05 significant level to reject the null hypothesis. The results indicate that faces do not produce more effective decisions with respect to trend determination. The result of the Wilcoxon Sign-Rank test is provided as Table 11.

Test for Decision Confidence - Hypothesis Five

NULL HYPOTHESIS: Individuals will feel as confident using the faces presentation mode as they will using the tabular presentation mode.

ALTERNATE HYPOTHESIS: Individuals will feel less confident when using faces than they will when using tables.

TABLE 10

Trend Detection

A. Decision Times (in seconds)

MODE	MEAN	STANDARD DEVIATION	COUNT	MINIMUM	MAXIMUM
FACES	93.73	32.61	30	38.00	192.0
TABLES	72.77	29.56	30	43.00	196.0

B. Decision Accuracy (correct answers out of four)

FACES	2.000	7.878E-01	30	0.000	3.000
TABLES	2.300	8.769E-01	30	1.000	4.000

C. Decision Effectiveness

FACES	87.39	54.77	30	0.00	284.2
TABLES	127.90	70.60	30	36.73	334.9

To test for decision confidence, participants were asked to respond to six statements dealing with their perceived confidence in answering the experiment questions, and their confidence in the mode of presentation (based on perceived ease of use and accuracy). Three statements dealt with the use of faces and the other three dealt with the use of faces. Responses to the statements were based on a five point Likert scale, with five being the most confident, and one the least confident. The results of the survey are shown in Table 12.

TABLE 11

Sign-Rank Test for Trend Detection Decision Effectiveness

WILCOXON'S SIGNED RANK TEST FOR Face Trend Effectiveness - Table Trend Effectiveness

SUM OF NEGATIVE RANKS	-342.0
SUM OF POSITIVE RANKS	123.0
NORMAL APPROXIMATION WITH CONTINUITY CORRECTION	-2.242
TWO TAILED P VALUE FOR NORMAL APPROXIMATION	0.0250

TOTAL NUMBER OF VALUES WHICH WERE TIED	0
NUMBER OF ZERO DIFFERENCES DROPPED	0
MAX. DIFF. ALLOWED BETWEEN TIES	1.00E-05

CASES INCLUDED 30   MISSING CASES 0

DECISION RULE: REJECT THE NULL HYPOTHESIS IF NORMAL APPROXIMATION > 1.645

Both populations, faces confidence level and tables confidence level, are normally distributed based on the Wilk-Shapiro test for normality. Therefore, the paired t test in STATISTIX was used to test the hypotheses. The results of the paired t test are shown as Table 13. The difference in confidence levels is significant at the 0.05 level and the null hypothesis is rejected. The results indicate that the participants felt less confident making decisions using faces than they did when making decisions using tables.

<u>Test to Determine if Individuals Would Use Faces in Jobs</u>

To measure if individuals would use the faces technique in their jobs they were asked to respond to the statement "If I had the opportunity I would use the faces format my job." The responses were made on a five

point Likert scale. A response of five meant that the individual strongly agreed with the statement and a response of 1 meant that the individual strongly disagreed with the statement. Table 14 is a summary of the responses to that statement. The response shows that 40 percent of the participants would consider the use of faces in their jobs.

TABLE 12

Survey Responses to Decision Making Confidence Statements

SURVEY STATEMENT	MEAN	STANDARD DEVIATION	N	COMMENT
ONE	2.650	1.060	30	Faces - Perceived Confidence
TWO	4.083	8.313E-01	30	Tables - Perceived Confidence
THREE	2.500	1.137	30	Faces - Perceived Accuracy
FOUR	4.533	7.761E-01	30	Tables - Perceived Accuracy
FIVE	3.100	1.348	30	Faces - Perceived Ease of Use
SIX	4.117	0.962	30	Tables - Perceived Ease of Use
FACE TOTAL	8.250	3.059	30	Sum of ONE, THREE, and FIVE
TABLE TOTAL	12.730	2.067	30	Sum of TWO, FOUR, and SIX

TABLE 13

Decision Making Confidence Vs Presentation Mode

PAIRED T TEST FOR Face Confidence - Table Confidence

MEAN	-4.483	STD ERROR	7.851E-01
T	-5.71		
DF	29		
P	0.0000		

CASES INCLUDED 30   MISSING CASES 0

DECISION RULE - REJECT NULL HYPOTHESIS IF T > 1.699

TABLE 14

Willingness of Individuals to Use Face Format

RESPONSE TO FIVE POINT LIKERT SCALE

VALUE	N	PERCENT	HISTOGRAM
1.000	5	16.67	********************
2.000	13	43.33	**
3.000	7	23.33	****************************
4.000	4	13.33	****************
5.000	1	3.34	****

Totals

MEAN	STANDARD DEVIATION	N
2.417	0.18	30

Test to Determine Impact of Experience on Decision Effectiveness - Hypothesis Six

NULL HYPOTHESIS: Individuals without experience in analyzing cost performance data will score the same on decision making effectiveness when analyzing face data as those individuals with cost performance report experience.

ALTERNATE HYPOTHESIS: Individuals without experience in analyzing cost performance data will not score the same on decision making effectiveness when analyzing face data as those individuals with cost performance report experience.

During the experiment, participants were asked to list the amount of experience they had in using C/SCSC. This was used as a measure of their experience in using cost performance data. To test the above hypothesis the scores for decision effectiveness of those having less than one year experience were compared with the scores of those having more than one year experience. A summary of that data is shown in Table 15.

Because the distributions failed the Wilk-Shapiro test for normality, the Wilcoxon Sign rank test was used to test the hypotheses. The results of this test are shown in Table 16. The differences in decision making effectiveness was not significant at the 0.05 level. The null hypothesis is not rejected. The data indicate that the level of cost performance experience did not have an effect on decision making effectiveness when faces were used.

TABLE 15

Comparison of Experiment Data: Experience Vs No Experience

A. Decision Times (in seconds)

EXPERIENCE	MEAN	STANDARD DEVIATION	COUNT	MINIMUM	MAXIMUM
NO	385.3	98.57	21	251.0	556.0
YES	329.8	134.1	9	138.0	566.0

B. Decision Accuracy (correct answers out of 12)

EXPERIENCE	MEAN	STANDARD DEVIATION	COUNT	MINIMUM	MAXIMUM
NO	7.524	1.750	21	4.000	11.00
YES	8.000	1.414	9	7.000	11.00

C. Decision Making Effectiveness

EXPERIENCE	MEAN	STANDARD DEVIATION	COUNT	MINIMUM	MAXIMUM
NO	75.29	25.95	21	31.65	126.€
YES	104.5	56.79	9	50.88	216.4

TABLE 16

Decision Making Effectiveness for Faces Mode Vs Experience

WILCOXON'S SIGNED RANK TEST FOR Experience VS No Experience

SUM OF NEGATIVE RANKS	-15.00
SUM OF POSITIVE RANKS	30.00
EXACT PROBABILITY OF A RESULT AS OR MORE EXTREME THAN THE OBSERVED RANKS (1 TAILED P VALUE)	0.2168
NORMAL APPROXIMATION WITH CONTINUITY CORRECTION	0.829
TWO TAILED P VALUE FOR NORMAL APPROXIMATION	0.4069

TOTAL NUMBER OF VALUES WHICH WERE TIED 0
NUMBER OF ZERO DIFFERENCES DROPPED 0
MAX. DIFF. ALLOWED BETWEEN TIES 1.00E-05

CASES INCLUDED 9 MISSING CASES 12

DECISION RULE: REJECT NULL HYPOTHESIS IF NORMAL APPROXIMATION < -1.96
OR NORMAL APPROXIMATION > 1.96

Impact Of Learning - Hypothesis Seven

NULL HYPOTHESIS: During the experiment learning did not occur and decision making effectiveness was the same in both halves of the experiment.

ALTERNATE HYPOTHESIS: During the experiment learning occurred in such a way that decision making effectiveness was greater in the bottom half of the experiment.

During the evaluation of the experiment results, it became evident that learning had taken place during the experiment. By dividing the experiment into halves, one can see that decision making effectiveness was much greater during the second half. Since the eight data sets used in the experiment were distributed so that each individual data set appeared in the top half (first four data sets) as many times as it appeared in the bottom half (last four data sets), this comparison could be made. Table 17 shows the comparison of decision making effectiveness for both halves of the experiment.

A one-sided paired t test was used to evaluate the impact of learning on decision making effectiveness when faces where used. The results of the paired t test are shown in Table 18. The difference in decision making effectiveness is significant at the 0.05 level. The null hypothesis is rejected. The results indicate that learning occurred during the experiment, and as a result, decision making effectiveness increased.

Impact of Teaching on the Use of Facial Presentation

The second experiment that was performed was exactly the same as the first with one exception. In the second experiment, participants were given five minutes of instruction how to analyze cost performance data

TABLE 17

Decision Making Effectiveness: Summary of Faces Experiment
Data for Both Halves of Experiment

PRESENTATION MODE: FACES

HALF	MEAN	STANDARD DEVIATION	COUNT	MINIMUM	MAXIMUM
FTOPEFF	66.68	39.31	30	18.18	197.8
FBOTEFF	116.9	53.45	30	22.36	234.8

TABLE 18

Paired t Test for Decision Making
Effectiveness Vs Experiment Half

PAIRED T TEST FOR Bottom Half efficiency - Top Half Efficiency

MEAN	50.20	STD ERROR	9.542
T	5.26		
DF	29		
P	0.0000		

CASES INCLUDED 30   MISSING CASES 0

DECISION RULE: REJECT THE NULL HYPOTHESIS IF T > 1.699

using the faces data presentation data. This section provides a comparison of experimental results between the second and first experiments. The comparisons are limited to cases involving the faces data presentation mode only. This limitation is used since the only difference in experiment construction involves the faces. (Further analysis has shown that the change did not have any significant impact,

at the 0.05 level, on decision making effectiveness and decision making confidence when the tabular format was used.)

Impact of Teaching on Decision Making Effectiveness

To test for the impact of teaching on decision making effectiveness, effectiveness data from both experiments were compared. Since decision making effectiveness is a function of both decision speed and decision accuracy, hypotheses related to decision speed and decision accuracy were tested as well as a hypothesis related to decision making effectiveness. A one sided paired t test was used to test each set of hypotheses. The experiment data for each case is summarized in Table 19.

Decision Speed - Hypothesis Eight.

NULL HYPOTHESIS: Individuals who received the five minute instruction on the use of faces will answer the faces related questions as fast as those who did not receive the instruction.

ALTERNATE HYPOTHESIS: Individuals who received the five minute instruction will answer the faces questions faster than those who did not receive the instruction.

The one-sight paired t test for this case is shown in Table 20. The difference in decision times is significant at the 0.05 level. The results indicate that the application of the five minute teaching resulted in faster decisions.

Decision Accuracy - Hypothesis Nine.

NULL HYPOTHESIS: Individuals who received the five minute instruction on the use of faces will answer the faces related questions as accurately (based on number of correct answers) as those who did not receive the instruction.

ALTERNATE HYPOTHESIS: Individuals who received the five minute instruction will answer the faces questions more accurately than those who did not receive the instruction.

The one sided paired t test for this case is shown in Table 21. The difference in correct answers for the two conditions is not significant at the 0.05 level. The results indicate that the use of the five minute instruction did not result in more accurate decisions.

TABLE 19

Comparison of Experiment Data:
5 Minute Teaching Vs. No Teaching

A. Decision Times (in seconds)

TEACHING?	MEAN	STANDARD DEVIATION	COUNT	MINIMUM	MAXIMUM
NO	368.7	111.0	30	138.0	566.0
YES	323.0	77.36	20	206.0	475.0

B. Decision Accuracy (correct answers out of twelve)

TEACHING?	MEAN	STANDARD DEVIATION	COUNT	MINIMUM	MAXIMUM
NO	7.667	1.647	30	4.000	11.00
YES	7.800	1.824	20	4.000	11.00

C. Decision Effectiveness

TEACHING?	MEAN	STANDARD DEVIATION	COUNT	MINIMUM	MAXIMUM
NO	84.05	39.24	30	31.65	216.4
YES	91.31	31.52	20	56.69	180.8

TABLE 20

Paired t Test for Decision Speed Vs Teaching

PAIRED T TEST FOR Speed/Teaching - Speed/No Teaching

MEAN	-67.50	STD ERROR	27.95
T	-2.42		
DF	19		
P	0.0260		

CASES INCLUDED 20   MISSING CASES 10

DECISION RULE - REJECT NULL HYPOTHESIS IF $T < -1.729$

TABLE 21

Paired t Test for Decision Accuracy Vs Teaching

PAIRED T TEST FOR Accuracy/Teaching - Accuracy/No Teaching

MEAN	4.500E-01	STD ERROR	5.305E-01
T	0.85		
DF	19		
P	0.4069		

CASES INCLUDED 20   MISSING CASES 10

DECISION RULE - REJECT NULL HYPOTHESIS IF $T > 1.729$

Decision Making Effectiveness - Hypothesis Ten.

NULL HYPOTHESIS: Individuals who received the five minute instruction on the use of faces will score the same in decision making effectiveness when answering faces related questions as those who did not receive the instruction.

ALTERNATE HYPOTHESIS: Individuals who received the five minute instruction will score higher in decision making effectiveness than those who did not receive the instruction.

The results of the one-sided paired t tests for this case is shown in Table 22. The difference in decision making effectiveness was sufficient at the 0.05 level to reject the null hypothesis. The results indicate that the use of the five minute teaching session did result in more effective decision making.

TABLE 22

Paired t Test for Decision Making Effectiveness vs Teaching

PAIRED T TEST FOR Effect/Teaching - Effect/No Teaching

MEAN	18.56	STD ERROR	9.834
T	1.89		
DF	19		
P	0.0744		

CASES INCLUDED 20 MISSING CASES 10

DECISION RULE - REJECT NULL HYPOTHESIS IF T > 1.729

The increase in decision making effectiveness can be primarily attributed to the significant decrease in the time taken to make the decision. Although decision accuracy did increase, the increase was not significant enough to be a vital factor in the increase to decision making effectiveness.

Impact of Teaching on Decision Making Confidence - Hypothesis Eleven.

NULL HYPOTHESIS: Individuals who received the teaching will be as confident when making decisions using faces as those individuals who did not receive the teaching.

ALTERNATE HYPOTHESIS: Individuals who received the teaching will be more confident making decisions using faces than those who did not receive the teaching.

To test for the impact on decision making confidence that occurs when experiment participants are given a five minute teaching on how to use the faces to analyze cost performance, the results of the responses to the survey statements dealing with decision making confidence from both experiments were compared. Again, only those responses dealing with faces were compared. Table 23 shows a summary of survey results. A one-sided paired t test was used to test for the impact of the teaching on decision making confidence. The results of the t test are shown in Table 24. The difference in decision making confidence is sufficient enough at the 0.05 significance level to reject the null hypothesis. The results indicate that those individuals who received a five minute teaching concerning the use of the faces data presentation technique were more confident when making decisions based on data presented as faces than those who did not receive the teaching.

Impact of Teaching on Willingness of Individuals to Use the Faces Format - Hypothesis Twelve

NULL HYPOTHESIS: Individuals who received the five minute instruction on the use of faces will be as likely to use the faces format in their jobs, if given the opportunity, as those who did not receive the instruction.

ALTERNATE HYPOTHESIS: Individuals who received the five minute instruction on the use of faces will more likely to use the faces format in their jobs, if given the opportunity, than those who did not receive the instruction.

To test for the impact of the five minute teaching session on the use of faces on the individuals willingness to use the faces in there job, the responses to statement eight ("If I had the opportunity I would use

the faces format in my job") of the survey was compared between both experiments. Responses were given on a five point likert scale with a score of "5" indicating that the individual strongly agreed with the statement and a score of "1" indicating that the individual strongly disagreed with the statement. A summary of responses to this statement

TABLE 23

Survey Responses to Decision Making Confidence Statements

SURVEY STATEMENT	TEACHING	MEAN	STANDARD DEVIATION	COUNT	COMMENT
ONE	N	2.650	1.060	30	Perceived Confidence
ONE	Y	3.300	0.979	20	Perceived Confidence
THREE	N	2.500	1.137	30	Perceived Accuracy
THREE	Y	3.100	8.522E-01	20	Perceived Accuracy
FIVE	N	3.100	1.348	30	Perceived Ease of Use
FIVE	Y	3.700	1.129	20	Perceived Ease of Use
TOTAL	N	8.250	3.059	30	Total - No Teaching
TOTAL	Y	10.10	2.573	20	Total - Teaching

TABLE 24

Paired t Test for Decision Making Confidence Vs. Teaching

PAIRED T TEST FOR Conf/Teaching - Conf/No Teaching

MEAN	1.900	STD ERROR	8.912E-01
T	2.13		
DF	19		
P	0.0463		

CASES INCLUDED 20 MISSING CASES 10

DECISION RULE - REJECT NULL IF T > 1.729

for both experiments is shown in Table 25. A one-sided (right-tailed) paired t test was used to test the hypotheses. Results of the test are shown in Table 26. The difference in responses was not significant at the 0.05 level. The results indicate that sufficient data do not exist to conclude that those who receive instruction on the use of the faces format are more likely to use the faces format in their jobs. Table 27 shows a breakdown of the second experiment's survey data for question eight. The data show that sixty percent of the participants who received the teaching would consider using the faces format in their job.

TABLE 25

Survey Responses to Survey Statement # 8

TEACHING	MEAN	STANDARD DEVIATION	COUNT	MEDIAN	MINIMUM
NO	2.417	1.018	30	1.000	5.000
YES	3.000	1.338	20	1.000	5.000

TABLE 26

Paired t Test for Willingness to Use Faces Vs Teaching

PAIRED T TEST FOR Eight/Teaching - Eight/No Teaching

MEAN	5.500E-01	STD ERROR	3.662E-01
T	1.50		
DF	19		
P	0.1495		

CASES INCLUDED 20   MISSING CASES 10

DECISION RULE: REJECT THE NULL HYPOTHESIS IF T > 1.699

TABLE 27

Willingness of Individuals to Use Face Format
after Receiving Teaching on the Use of Faces

RESPONSE TO FIVE POINT LIKERT SCALE

VALUE	COUNT	PERCENT	HISTOGRAM
1.000	3	15	******************************
2.000	5	25	**
3.000	4	20	**
4.000	5	25	**
5.000	3	15	******************************

V. Conclusions and Recommendations

In Chapter 1, four investigative questions were set forth as the objective of this research study. Each question is restated in this chapter with a discussion of whether that objective was achieved, and if so, how it was achieved.

Investigative Question 1

How can the method of facial representation be PC based?

Although several "faces" programs have been written, none have been written for use on a PC. Although some of those programs could have been modified by the investigator for use on a PC, the investigator chose to develop his own. This program is shown in Appendix A. It is written specifically for the analysis of CPR data. The program was written using QuickBasic and has been developed as a "stand alone" program. That is, the program has been converted so that the user does not need QuickBasic to run it. The program does require that the computer utilize the MS DOS operating system. Modifications to the program must be made within the QuickBasic environment.

The CPR FACES program can be contained on a standard 360K floppy disk. This makes it easily transferable from user to user. It can be operated on any IBM compatible computer with EGA graphics. The potential exists for widespread use of the program among Air Force program personnel.

Investigative Question 2

What CPR variables should be selected for use in the CPR FACES program and which facial characteristics should be tied to each variable?

Air Force contractor cost performance report data are primarily described by five variables. These variables are: Budgeted Cost of Work Performed (BCWP), Budgeted Cost of Work Scheduled (BCWS), Actual Cost of Work Performed (ACWP), Budget at Completion (BAC), and Estimate at Completion (EAC). From these five variables, one can calculate several measures of performance including Cost Variance (CV), Schedule Variance (SV), Cost Performance Index (CPI), Schedule Performance Index (SPI), and To Complete Performance Index (TCPI). Because they are the fundamental blocks of CPR data, four variables (BCWP, BCWS, ACWP, and BAC) were chosen as inputs to the CPR FACES program. (The EAC can be computed from BCWP, ACWP, and BAC.) The CPR FACES program does not match those four variables with facial characteristics. Instead, it uses them to calculate the five measures of performance mentioned above. The actual pairings are described in Appendix A. The pairings reflect the preference of the investigator. A study on how different pairings may impact the effectiveness of the faces is left as a recommendation for further study. None of the research studies reviewed in the literature review (Chapter II) included a basis or theory for assigning variables to facial features.

Investigative Question 3

> How effective is facial representation in conveying cost performance measurement data?

This research shows that an individual using faces for the first time would probably have difficulty making decisions based on those faces. The individual would perform better using tabular data. Further research revealed that an individual who received training in the use of faces would make more effective decisions than one who received no training. The low decision effectiveness scores can be primarily attributed to the participant's unfamiliarity with the concept. The effectiveness scores have been compared to those achieved using tabular data. Individuals are much more familiar with tabular data. CPR data are traditionally reported in tabular form.

The potential exists for facial representation to become an effective decision making tool. The two factors that may facilitate this are training and experience.

Investigative Question 4

> How does a person's level of experience impact the usefulness of the faces method?

Individuals possessing greater than one year of experience in cost performance analysis scored higher (though not significantly) in decision making effectiveness when using faces than those with less than one year experience. They also scored higher when using tabular data. The higher scores can be attributed to their higher experience level, however, experience can not be said to have made a significant impact on the usefulness of the faces method.

Conclusion

The usefulness of facial representation as an analytical or decision making tool in the realm of cost performance measurement has been subjected to two primary concerns. The first concern was that it had to be PC based. This was accomplished through the development of the CPR FACES program. The second concern was that the use of faces would lead to effective decision making. The fulfillment of this is not as clear. Faces did not lead to as effective decision making as did tabular data. However, training and experience significantly increase effectiveness. The degree of training and experience needed to raise the level of effectiveness to a standard at least equal to that of the tabular method is uncertain.

One possible use of the faces may be as a companion to tabular data. The CPR FACES program would serve well in this capacity. The program output displays the faces above the corresponding tabular data. The user has both tools available to him/her.

Although the research analysis has shown that the use of the faces method resulted in lower decision making effectiveness than the use of tabular data, it has also shown that potential exists to make it an effective analytical and decision making tool. Further research should be done to explore these areas of potential.

Recommendations

This research examined the effectiveness of the faces method of presenting CPR data as compared to the tabular method. It did not compare the effectiveness of using both methods simultaneously as a decision making tool. Combining the attributes of the two methods may

prove to be an effective decision making tool. A comparison of this combined method with both the faces method and the tabular method is encouraged.

This research showed that training in the use of faces significantly increased decision making effectiveness. The training provided consisted only of a five minute lecture and a handout describing how the CPR variables and facial features were paired. This area of study is still wide open for further research. An investigator could compare different degrees of training and experience in the use of faces to determine what, if any, is an optimum amount. Research is needed to determine if there is a level of training and experience that would make the faces method as useful (in terms of decision making effectiveness) as the tabular method.

The CPR data/facial feature pairings are the basis for an additional area of research. The pairings developed in the CPR FACES program are strictly based on personal preference of the investigator. It may not represent the optimal pairings, if such optimal pairings exist. One possible study could alter these pairings and determine the impact on decision making effectiveness.

This research did not take into account the decision styles and preferences of the individual participants. In her research, Grigware (6) studied the effectiveness of various graphical data presentation methods as well as the tabular method. As one aspect of her research, she used a test to classify experiment participants as being field dependent or field independent. Field independent individuals are characterized as being more analytical than field dependent individuals. The field independent individuals scored much higher than the field

dependent individuals when graphs were used (7:10, 39). Similar research could be done in the realm of facial representation to determine if the faces method appeals more to specific decision making styles.

Research in these areas are warranted in order to determine whether facial representation can be a viable cost performance measurement tool. Present research indicates that the potential exists. The CPR FACES program, which is inexpensive to duplicate and easy to use, has been developed and should facilitate further research.

Appendix A: CPR FACES Program

Program Overview

The CPR FACES program was written using QuickBasic (10). The intent of the program is to transform Cost Performance Report (CPR) data into cartoon faces similar to those developed by Chernoff (1). Unlike other faces programs that have previously been written, the CPR FACES is written specifically for CPR data. The CPR FACES program was also developed so that it could easily be used on a personal computer (PC). Previous faces programs have been written specifically for main-frame computers. The PC base gives the program wider usefulness. It makes the program available to all Air Force program officers.

Program Characteristics

A primary feature of the faces concept is the ability of the faces to show the interaction between variables. Previous programs have used complex algorithms in order to tie variables together. The CPR FACES program avoided the use of such algorithms because of the interaction already inherent with CPR variables. For example, two variables portrayed by the CPR FACES experiment are cost variance (CV) and to complete performance index (TCPI). Both CV and TCPI use as an input the actual cost of work planned (ACWP). As ACWP changes so does CV and TCPI. The CPR FACES program reflects the changes to both simultaneously.

To draw the faces, BASIC's graphic functions were employed. Conversion factors were developed and used to convert the CPR data to

inputs for BASIC's graphic's commands (such as the CIRCLE command where the inputs are radius and eccentricity). The CPR variable/facial feature pairings used in the program are as follows:

Shape of Face - TCPI,
Eyebrow Position - Cost Variance,
Pupil Position - Schedule Variance,
Curvature of the Mouth - Cost Performance Index, and
Nose Length - Schedule Performance Index.

Program Operation

The program was written so that the user could enter CPR data by the use of a data file, "a:cpr.dat." The user can enter up to eight cases, with four cases being the maximum that can be displayed on one screen. The program uses the following as inputs from the user: BCWS, BCWP, ACWP, and BAC. The computer computes CV, SV, CPI, and SPI for each case. The faces are drawn and a listing of BCWP, BCWS, ACWP, SV, CV, CPI, and SPI is produced.

The first faces screen that is produced during each operation is designed to illustrate what a very good, very bad, and neutral face should look like. The following two screens are faces and data based on the user's inputs. Once the user becomes familiar with the CPR FACES output, he/she can delate the first screen with very little to the program.

Unfortunately, the CPR FACES program does not include an option that allows the user to print the output. The author used WordPerfect 5.0's "grab" utility to import the faces output into a WordPerfect 5.0 text file. One can learn this procedure by consulting the WordPerfect 5.0 documentation (14).

The QuickBasic program code is listed below with appropriate comments. A sample program output is shown after the code listing.

CPR FACES Program

```
'                              Main Program

DECLARE SUB Ifi ()
DECLARE SUB ichart ()
DECLARE SUB Ifa ()
DECLARE SUB chart2 ()
DECLARE SUB intro ()               'Declare Subroutines
DECLARE SUB define ()
DECLARE SUB set3faceinfo ()
DECLARE SUB set3faces ()
DECLARE SUB faces ()
DECLARE SUB cprinfo ()
DECLARE SUB FaceInfo ()
DECLARE SUB Table ()
DECLARE SUB chart ()

'                         Define Variables

COMMON SHARED a, r, mr, er, ear, pr, era, eara, b$
COMMON SHARED bc(), mc(), nl(), ef(), pf()
COMMON SHARED bcwp(), bcws(), acwp(), cv(), cvp(), svp(), bac()
COMMON SHARED cpi(), spi(), pc(), ps(), tcpi()
COMMON SHARED yn(), yel(), x1(), x2(), sv()

DIM bc(35), mc(35), nl(35), ef(35), pf(35)
DIM bcwp(35), bcws(35), acwp(35), cv(35), cvp(35), svp(35), bac(35)
DIM cpi(35), spi(35), pc(35), ps(35), tcpi(35)
DIM yn(35), yel(35), x1(35), x2(35), sv(35)
DIM introtext$(24)


CLS
OPEN "a:cpr.dat" FOR INPUT AS #2

a = 1
5
INPUT #2, bcws(a), bcwp(a), acwp(a), bac(a)

IF a = 8 GOTO 6
a = a + 1
GOTO 5
```

```
6

bcws(9) = 2000
bcwp(9) = 4000
acwp(9) = 2000
bac(9) = 15000
bcws(10) = 10000
bcwp(10) = 4000
acwp(10) = 7000
bac(10) = 15000    ' CPR Data for sample faces
bcws(11) = 4000
bcwp(11) = 4000
acwp(11) = 4000
bac(11) = 15000

intro

CLS
OPEN "a:input.txt" FOR INPUT AS #3
VIEW PRINT 1 TO 24
b = 1
9
LINE INPUT #3, introtext$(b)
PRINT introtext$(b)

b = b + 1
IF b < 22 GOTO 9

3
LOCATE 23, 10
PRINT "Press Any Key to Continue"
hit$ = INKEY$
IF hit$ <> "" THEN GOTO 4 ELSE GOTO 3
4

CLS 0

cprinfo
Ifi                'DRAW SAMPLE FACES AND TABLE
Ifa
ichart

31
LOCATE 23, 10
PRINT "Press Any Key to Continue"
hit$ = INKEY$
IF hit$ <> "" THEN GOTO 41 ELSE GOTO 31
41

10
CLS 0
FaceInfo
faces                    'DRAW SCREEN 1 FACES AND TABLE
```

```
20
chart

21

LOCATE 23, 10
PRINT "Press Any Key to Continue"
hit$ = INKEY$
IF hit$ <> "" THEN GOTO 30 ELSE GOTO 21

30

CLS 0
set2faceinfo        'DRAW SCREEN 2 FACES AND TABLE
set2faces
chart2

40
LOCATE 23, 10
PRINT "Press Any Key to Continue"
hit$ = INKEY$
IF hit$ <> "" THEN GOTO 90 ELSE GOTO 40


90
CLS 0
VIEW PRINT 1 TO 24
LOCATE 4, 1
PRINT "This completes the faces demo."
99

END
```

```
'                         SUBROUTINES


SUB chart                  'CPR TABULAR DATA FOR DATA SCREEN 1

VIEW PRINT 13 TO 24
LOCATE 15, 1
PRINT "           BCWS      BCWP      ACWP      SV        CV        SPI
    CPI"
LOCATE 17, 1
PRINT USING "    A  ######    ######    ######    ######    ######
##.###    ##.###"; bcws(1); bcwp(1); acwp(1); sv(1); cv(1); spi(1);
cpi(1)
LOCATE 18, 1
PRINT USING "    B  ######    ######    ######    ######    ######
##.###    ##.###"; bcws(2); bcwp(2); acwp(2); sv(2); cv(2); spi(2);
cpi(2)
```

```
LOCATE 19, 1
PRINT USING "    C  ######   ######   ######   ######   ######
##.###    ##.###"; bcws(3); bcwp(3); acwp(3); sv(3); cv(3); spi(3);
cpi(3)
LOCATE 20, 1
PRINT USING "    D  ######   ######   ######   ######   ######
##.###    ##.###"; bcws(4); bcwp(4); acwp(4); sv(4); cv(4); spi(4);
cpi(4)

END SUB

' ____________________________________________________

SUB chart2          'CPR TABULAR DATA FOR DATA SCREEN 2

VIEW PRINT 13 TO 24
LOCATE 15, 1
PRINT "         BCWS     BCWP     ACWP      SV        CV        SPI
     CPI"
LOCATE 17, 1
PRINT USING "    A  ######   ######   ######   ######   ######
##.###    ##.###"; bcws(5); bcwp(5); acwp(5); sv(5); cv(5); spi(5);
cpi(5)
LOCATE 18, 1
PRINT USING "    B  ######   ######   ######   ######   ######
##.###    ##.###"; bcws(6); bcwp(6); acwp(6); sv(6); cv(6); spi(6);
cpi(6)
LOCATE 19, 1
PRINT USING "    C  ######   ######   ######   ######   ######
##.###    ##.###"; bcws(7); bcwp(7); acwp(7); sv(7); cv(7); spi(7);
cpi(7)
LOCATE 20, 1
PRINT USING "    D  ######   ######   ######   ######   ######
##.###    ##.###"; bcws(8); bcwp(8); acwp(8); sv(8); cv(8); spi(8);
cpi(8)

END SUB

' ____________________________________________________

SUB cprinfo       'CALCULATES SV, CV, CPI, SPI, AND TCPI

6000
a = 1
6100
IF a > 11 THEN GOTO 6200

cv(a) = bcwp(a) - acwp(a)       'cost variance
sv(a) = bcwp(a) - bcws(a)       'schedule variance
cvp(a) = cv(a) / bcwp(a)        'cost variance percentage
svp(a) = sv(a) / bcws(a)        'schedule variance percentage
'
'       Performance Indices
```

```
'
cpi(a) = bcwp(a) / acwp(a)      'Cost Performance Index
spi(a) = bcwp(a) / bcws(a)      'Schedule Performance Index
'
pc(a) = bcwp(a) / bac(a)        'Percent complete
ps(a) = acwp(a) / bac(a)        'percent spent
'
tcpi(a) = (bac(a) - bcwp(a)) / (bac(a) - acwp(a))
a = a + 1
GOTO 6100

6200

END SUB

' ___________________________________________

SUB FaceInfo   'CONVERTS CPR DATA TO FACES INPUTS

r = 25       'face radius
mr = 10      'mouth radius
er = 7       'eye radius
ear = 3      'ear radius
pr = .75     'pupil radius
era = .5     'eye aspect ratio
eara = .8    'ear aspect ratio

a = 1
'
'        Input CPR Data
'
100
IF a > 4 GOTO 190
'
bc(a) = tcpi(a) * -.1 + 1
IF bc(a) > 1 THEN bc(a) = 1
IF bc(a) < .7 THEN bc(a) = .7
'
mc(a) = cpi(a) - 1
IF mc(a) < -1 THEN mc(a) = -1
IF mc(a) > 1 THEN mc(a) = 1
'
nl(a) = 5 + spi(a) * 5
IF nl(a) > 15 THEN nl(a) = 15
'
ef(a) = cvp(a) * 7
IF ef(a) < -7 THEN ef(a) = -7
IF ef(a) > 7 THEN ef(a) = 7
'
pf(a) = svp(a) * 10
IF pf(a) < -5 THEN pf(a) = -5
IF pf(a) > 5 THEN pf(a) = 5
a = a + 1
```

```
GOTO 100
190

END SUB

' ______________________________________________

SUB faces                    'DRAWS FACES FOR SCREEN 1
'
SCREEN 9
VIEW (15, 5)-(615, 125), 8, 4
WINDOW (0, 0)-(400, 100)

a = 1

'       Draw Face Outline

1000
IF a > 4 GOTO 1290

'

pi = 3.14

'

xface = (a * 100) - 50
CIRCLE (xface, 50), r, , 0, pi, 1 'top half
CIRCLE (xface, 50), r, , pi, 0, bc(a)'bottom half
'
'       Draw mouth curvature
'
IF mc(a) <= 0 GOTO 1100 ELSE GOTO 1150
'
1100 mc(a) = -mc(a)
CIRCLE (xface, 35), mr, , .2 * pi, .8 * pi, mc(a)

GOTO 1200
1150
CIRCLE (xface, 40), mr, , 1 * pi, 0 * pi, mc(a)
1200
'                               eyes
'
CIRCLE (xface - 10, 60), er, , , , era'left eye
CIRCLE (xface + 10, 60), er, , , , era'right eye
'
'       nose
'
yn(a) = 60 - nl(a)
LINE (xface, 60)-(xface + 3, yn(a))
LINE (xface + 3, yn(a))-(xface - 3, yn(a))
LINE (xface - 3, yn(a))-(xface, 60)
'
'       ears
'
```

```
CIRCLE (xface + 29, 50), ear, , , , eara
CIRCLE (xface - 29, 50), ear, , , , eara
'
'       eyebrows
'
IF ef(a) > 0 THEN GOTO 1225
yel(a) = 65 + ef(a)
LINE (xface - 5, 65)-(xface - 17, yel(a))
LINE (xface + 5, 65)-(xface + 17, yel(a))
GOTO 1250
1225
yel(a) = 65 - ef(a)
LINE (xface - 17, 65)-(xface - 5, yel(a))
LINE (xface + 17, 65)-(xface + 5, yel(a))
1250
'
'       pupils
'
x1(a) = (xface - 10) + pf(a)
x2(a) = (xface + 10) + pf(a)
CIRCLE (x1(a), 60), pr
PAINT (x1(a), 60)
CIRCLE (x2(a), 60), pr
PAINT (x2(a), 60)
a = a + 1
GOTO 1000
1290
VIEW PRINT 10 TO 24
LOCATE 11, 10
PRINT " A                    B                  C                  D"

END SUB

' ______________________________________________

SUB ichart    'TABULAR DATA FOR SAMPLE FACES

VIEW PRINT 13 TO 24
LOCATE 15, 1
PRINT "          BCWS      BCWP      ACWP      SV        CV        SPI
     CPI"
LOCATE 17, 1
PRINT USING "GOOD    ######    ######    ######    ######    ######
##.###    ##.###"; bcws(9); bcwp(9); acwp(9); sv(9); cv(9); spi(9);
cpi(9)
LOCATE 18, 1

LOCATE 19, 1
PRINT USING "NEUT    ######    ######    ######    ######    ######
##.###    ##.###"; bcws(11); bcwp(11); acwp(11); sv(11); cv(11);
spi(11); cpi(11)

END SUB
```

```
SUB Ifa        ' DRAWS SAMPLE FACES
'
SCREEN 9
VIEW (15, 5)-(615, 125), 8, 4
WINDOW (0, 0)-(400, 100)

a = 9

'       Draw Face Outline

31000
IF a > 11 GOTO 31290
'
pi = 3.14
'
xface = ((a - 8) * 100) - 50
CIRCLE (xface, 50), r, , 0, pi, 1 'top half
CIRCLE (xface, 50), r, , pi, 0, bc(a)'bottom half
'
'       Draw mouth curvature
'
IF mc(a) <= 0 GOTO 31100 ELSE GOTO 31150
'
31100
mc(a) = -mc(a)
CIRCLE (xface, 35), mr, , .2 * pi, .8 * pi, mc(a)

GOTO 31200
31150
CIRCLE (xface, 40), mr, , 1 * pi, 0 * pi, mc(a)
31200
'                                    eyes
'
CIRCLE (xface - 10, 60), er, , , , era'left eye
CIRCLE (xface + 10, 60), er, , , , era'right eye
'
'       nose
'
yn(a) = 60 - nl(a)
LINE (xface, 60)-(xface + 3, yn(a))
LINE (xface + 3, yn(a))-(xface - 3, yn(a))
LINE (xface - 3, yn(a))-(xface, 60)
'
'       ears
'
CIRCLE (xface + 29, 50), ear, , , , eara
CIRCLE (xface - 29, 50), ear, , , , eara
'
'       eyebrows
'
IF ef(a) > 0 THEN GOTO 31225
yel(a) = 65 + ef(a)
LINE (xface - 5, 65)-(xface - 17, yel(a))
```

```
LINE (xface + 5, 65)-(xface + 17, yel(a))
GOTO 31250
31225
yel(a) = 65 - ef(a)
LINE (xface - 17, 65)-(xface - 5, yel(a))
LINE (xface + 17, 65)-(xface + 5, yel(a))
31250
'
'        pupils
'
x1(a) = (xface - 10) + pf(a)
x2(a) = (xface + 10) + pf(a)
CIRCLE (x1(a), 60), pr
PAINT (x1(a), 60)
CIRCLE (x2(a), 60), pr
PAINT (x2(a), 60)
a = a + 1
GOTO 31000
31290
LOCATE 11, 10
PRINT " GOOD                BAD                NEUTRAL                    "

END SUB

' ________________________________________________

SUB Ifi      'CONVERTS CPR DATA TO FACES INPUTS FOR SAMPLE FACES

r = 25       'face radius
mr = 10      'mouth radius
er = 7       'eye radius
ear = 3      'ear radius
pr = .75     'pupil radius
era = .5     'eye aspect ratio
eara = .8    'ear aspect ratio


a = 9
'
'        Input CPR Data
'
30100
IF a > 11 GOTO 30190

'
bc(a) = tcpi(a) * -.1 + 1
IF bc(a) > 1 THEN bc(a) = 1
IF bc(a) < .7 THEN bc(a) = .7
'
mc(a) = cpi(a) - 1
IF mc(a) < -1 THEN mc(a) = -1
IF mc(a) > 1 THEN mc(a) = 1
'
```

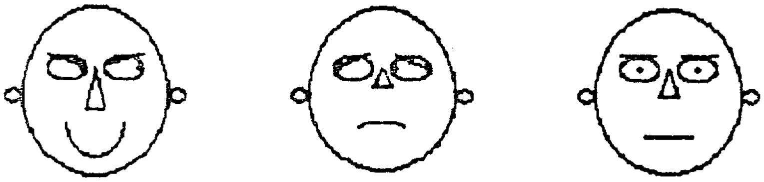
```
nl(a) = 5 + spi(a) * 5
IF nl(a) > 15 THEN nl(a) = 15
'
ef(a) = cvp(a) * 7
IF ef(a) < -7 THEN ef(a) = -7
IF ef(a) > 7 THEN ef(a) = 7
'
pf(a) = svp(a) * 10
IF pf(a) < -5 THEN pf(a) = -5
IF pf(a) > 5 THEN pf(a) = 5
a = a + 1
GOTO 30100
30190

END SUB

' ______________________________________________________


SUB intro '  TITLE SCREEN

CLS 0
VIEW PRINT 6 TO 24
LOCATE 7, 25
PRINT "Cost Performance Report Faces Demo"
LOCATE 8, 35
PRINT "by Capt Jeffrey Tkach"
LOCATE 9, 38
PRINT "AFIT/GSM"
LOCATE 10, 36
PRINT "September 1990"
1
LOCATE 21, 10
PRINT "Press Any Key to Continue"
hit$ = INKEY$
IF hit$ <> "" THEN GOTO 2 ELSE GOTO 1
2
CLS
END SUB

' ______________________________________________


SUB set2faceinfo   ' CONVERTS CPR DATA TO FACES INPUTS FOR SCREEN 2

r = 25      'face radius
mr = 10     'mouth radius
er = 7      'eye radius
ear = 3     'ear radius
pr = .75    'pupil radius
era = .5    'eye aspect ratio
eara = .8   'ear aspect ratio

a = 5
'
```

```
'        Input CPR Data
'
8100
IF a > 8 GOTO 8190
'
bc(a) = tcpi(a) * -.1 + 1
IF bc(a) > 1 THEN bc(a) = 1
IF bc(a) < .7 THEN bc(a) = .7
'
mc(a) = cpi(a) - 1
IF mc(a) < -1 THEN mc(a) = -1
IF mc(a) > 1 THEN mc(a) = 1
'
nl(a) = 5 + spi(a) * 5
IF nl(a) > 15 THEN nl(a) = 15
'
ef(a) = cvp(a) * 7
IF ef(a) < -7 THEN ef(a) = -7
IF ef(a) > 7 THEN ef(a) = 7
'
pf(a) = svp(a) * 10
IF pf(a) < -5 THEN pf(a  = -5
IF pf(a) > 5 THEN pf(a,  = 5
a = a + 1
GOTO 8100
8190

END SUB

' ______________________________________________

SUB set2faces   ''DRAWS FACES FOR SCREEN 2
'
SCREEN 9
VIEW (15, 5)-(615, 125), 8, 4
WINDOW (0, 0)-(400, 100)

a = 5

'        Draw Face Outline

9000
IF a > 8 GOTO 9290
'
pi = 3.14
'
xface = ((a - 4) * 100) - 50
CIRCLE (xface, 50), r, , 0, pi, 1 'top half
CIRCLE (xface, 50), r, , pi, 0, bc(a)'bottom half
'
'        Draw mouth curvature
'
IF mc(a) >= 0 GOTO 9150
```

```
'
9100 mc(a) = -mc(a)
CIRCLE (xface, 35), mr, , .2 * pi, .8 * pi, mc(a)
GOTO 9200
9150
CIRCLE (xface, 40), mr, , 1 * pi, 0 * pi, mc(a)
9200
'                            eyes
'
CIRCLE (xface - 10, 60), er, , , , era'left eye
CIRCLE (xface + 10, 60), er, , , , era'right eye
'
'       nose
'
yn(a) = 60 - ni(a)
LINE (xface, 60)-(xface + 3, yn(a))
LINE (xface + 3, yn(a))-(xface - 3, yn(a))
LINE (xface - 3, yn(a))-(xface, 60)
'
'       ears
'
CIRCLE (xface + 29, 50), ear, , , , eara
CIRCLE (xface - 29, 50), ear, , , , eara
'
'       eyebrows
'
IF ef(a) > 0 THEN GOTO 9225
yel(a) = 65 + ef(a)
LINE (xface - 5, 65)-(xface - 17, yel(a))
LINE (xface + 5, 65)-(xface + 17, yel(a))
GOTO 9250
9225
yel(a) = 65 - ef(a)
LINE (xface - 17, 65)-(xface - 5, yel(a))
LINE (xface + 17, 65)-(xface + 5, yel(a))
9250
'
'       pupils
'
x1(a) = (xface - 10) + pf(a)
x2(a) = (xface + 10) + pf(a)
CIRCLE (x1(a), 60), pr
PAINT (x1(a), 60)
CIRCLE (x2(a), 60), pr
PAINT (x2(a), 60)
a = a + 1
GOTO 9000
9290
VIEW PRINT 10 TO 12
LOCATE 11, 10
PRINT "  A                  B                  C                  D "

END SUB
```

CPR FACES Sample Output

Screen 1 - Examples

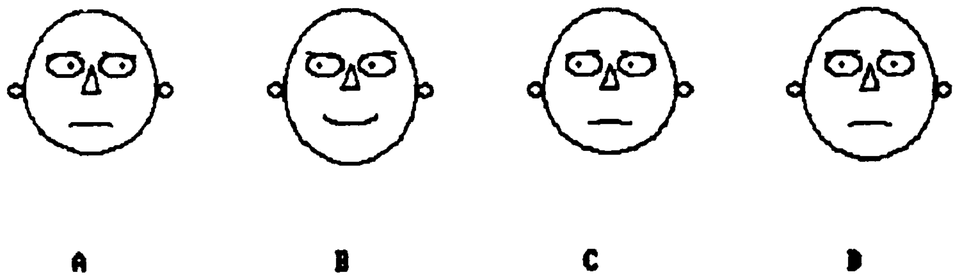


GOOD BAD NEUTRAL

	BCWS	BCWP	ACWP	SV	CV	SPI	CPI
GOOD	2000	4000	2000	2000	2000	2.000	2.000
BAD	10000	4000	7000	-6000	-3000	0.400	0.571
NEUT	4000	4000	4000	0	0	1.000	1.000

Press Any Key to Continue

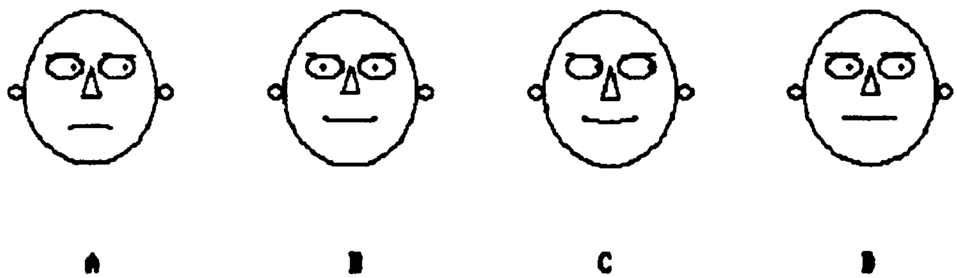
Screen 2 - First Four Data Sets



	BCWS	BCWP	ACWP	SV	CV	SPI	CPI
A	3000	3700	4400	700	-700	1.233	0.841
B	1700	1400	1100	-300	300	0.824	1.273
C	6000	4900	6000	-1100	-1100	0.817	0.817
D	10700	10000	11500	-700	-1500	0.935	0.870

Press Any Key to Continue

Screen 3 - Last Four Data Sets



	BCWS	BCWP	ACWP	SV	CV	SPI	CPI
A	2300	3000	3500	700	-500	1.304	0.857
B	3200	3000	2800	-200	200	0.938	1.071
C	2000	3000	2700	1000	300	1.500	1.111
D	7500	9000	9000	1500	0	1.200	1.000

Press any Key to Continue

Appendix B: Experiment Program

The experiment program was written in QuickBasic. It utilizes the CPR FACES program that was shown in Appendix A.

Two main features characterize this program. The first feature is the ability to save the participant's answers to the experiment questions to floppy disks. The second feature is the ability to record the amount of time that it takes the participant to answer the experiment questions.

Below is a partial listing of the code used to develop the experiment program. To eliminate redundancy in the text some subroutine codes have been omitted. The complete program code is available upon request.

Main Program

```
' Declare Subroutines

DECLARE SUB Ifi ()
DECLARE SUB Ichart ()
DECLARE SUB Ifa ()
DECLARE SUB chart3 ()
DECLARE SUB set7faceinfo ()
DECLARE SUB set7faces ()
DECLARE SUB chart4 ()
DECLARE SUB set5faces ()
DECLARE SUB set5faceinfo ()
DECLARE SUB questions5 ()
DECLARE SUB personal ()
DECLARE SUB chart2 ()
DECLARE SUB questions4 ()
DECLARE SUB questions3 ()
DECLARE SUB intro ()
DECLARE SUB define ()
DECLARE SUB set3faceinfo ()
DECLARE SUB set3faces ()
DECLARE SUB questions1 ()
DECLARE SUB questions2 ()
DECLARE SUB questions ()
```

```
DECLARE SUB Faces ()
DECLARE SUB cprinfo ()
DECLARE SUB FaceInfo ()
DECLARE SUB Table ()
DECLARE SUB chart ()
DECLARE SUB faceinfo2 ()
DECLARE SUB faces2 ()

' Declare Variables

COMMON SHARED a, r, mr, er, ear, pr, era, eara, b$
COMMON SHARED bc(), mc(), nl(), ef(), pf()
COMMON SHARED bcwp(), bcws(), acwp(), cv(), cvp(), svp(), bac()
COMMON SHARED cpi(), spi(), pc(), ps(), tcpi()
COMMON SHARED yn(), yel(), x1(), x2(), sv()

DIM bc(35), mc(35), nl(35), ef(35), pf(35)
DIM bcwp(35), bcws(35), acwp(35), cv(35), cvp(35), svp(35), bac(35)
DIM cpi(35), spi(35), pc(35), ps(35), tcpi(35)
DIM yn(35), yel(35), x1(35), x2(35), sv(35)
DIM introtext$(24)

'  Input Cost Performance Data from File "a:facedata.prn"

CLS
OPEN "a:facedata.prn" FOR INPUT AS #2

a = 1
5
INPUT #2, bcws(a), bcwp(a), acwp(a), bac(a)

IF a = 35 GOTO 6
a = a + 1
GOTO 5

6

'  Create data file "a:data,dat" for experiment responses.

OPEN "a:data.dat" FOR OUTPUT AS #1

intro

CLS

'  Open test file "a:input.txt" for experiment introduction.

OPEN "a:input.txt" FOR INPUT AS #3
VIEW PRINT 1 TO 24
b = 1
9
LINE INPUT #3, introtext$(b)
PRINT introtext$(b)
```

```
b = b + 1
IF b < 22 GOTO 9

3
LOCATE 23, 10
PRINT "Press Any Key to Continue"
hit$ = INKEY$
IF hit$ <> "" THEN GOTO 4 ELSE GOTO 3
4

' Call subroutine "personal" to collect background data on
' participant.

personal

' DRAW EXAMPLE FACES AND CORRESPONDING CPR DATA

CLS 0
cprinfo  ' Calls subroutine to calculate CPR information
Ifi      ' Calls subroutine to convert CPR data to Face data
Ifa      ' Calls subroutine to draw faces
Ichart

31
LOCATE 23, 10
PRINT "Press Any Key to Continue"
hit$ = INKEY$
IF hit$ <> "" THEN GOTO 41 ELSE GOTO 31
41

' EXPERIMENT DATA SET 1 - FACES

FaceInfo ' Calls subroutine to convert CPR data to face data

10

Faces   ' Calls subroutine to draw faces

WRITE #1, "SET 1"
questions1  ' Calls subroutine to display question set 1

' EXPERIMENT DATA SET 2 - TABLES

20
CLS 0
chart ' Calls subroutine to present data in table form
WRITE #1, "SET 2"

questions1 ' Calls subroutine to display questions

30  ' EXPERIMENT DATA SET 3 - FACES

CLS 0
```

```
set3faceinfo
set3faces
WRITE #1, "SET 3"
questions2

40 ' EXPERIMENT DATA SET 4 - TABLES

CLS 0
chart2
WRITE #1, "SET 4"
questions2

50 ' EXPERIMENT DATA SET 5 - FACES

CLS 0
set5faceinfo
set5faces
WRITE #1, "SET 5"
questions1

60 ' EXPERIMENT DATA SET 6 - TABLES

CLS 0
chart3
WRITE #1, "SET 6"
questions1

70 ' EXPERIMENT DATA SET 7 - FACES

CLS 0
set7faceinfo
set7faces
WRITE #1, "SET 7"
questions2

80 ' EXPERIMENT DATA SET 8 - TABLES

CLS 0
chart4
WRITE #1, "SET  8"
questions2

90 ' NOTICE OF EXPERIMENT COMPLETION

CLS 0
VIEW PRINT 1 TO 24
LOCATE 4, 1
PRINT "That completes this portion of the experiment."
LOCATE 6, 1
PRINT "Please raise your hand to indicate that you have finished."
LOCATE 8, 1
PRINT "Disobey the next command by not pressing any key to continue."
99 END
```

SUBROUTINES

NOTE: Because several subroutines are similar, some are omitted in this test. Those subroutines which are omitted will be identified.

```
SUB chart   '     Lists Tabular Data on Output Screen

CLS
VIEW PRINT 1 TO 11
LOCATE 1, 5
PRINT "                                                    SCHEDULE
COST"
LOCATE 2, 5
PRINT "ELEMENT        BCWS        BCWP        ACWP        VARIANCE
VARIANCE"
LOCATE 4, 5
PRINT USING "    A         ######      ######      ######       ######
 ######"; bcws(5); bcwp(5); acwp(5); sv(5); cv(5)
LOCATE 5, 5
PRINT USING "    B         ######      ######      ######       ######
 ######"; bcws(6); bcwp(6); acwp(6); sv(6); cv(6)
LOCATE 6, 5
PRINT USING "    C         ######      ######      ######       ######
 ######"; bcws(7); bcwp(7); acwp(7); sv(7); cv(7)
LOCATE 8, 5
PRINT USING "  TOTAL       ######      ######      ######       ######
 ######"; bcws(8); bcwp(8); acwp(8); sv(8); cv(8)

END SUB

SUB chart2   'OMITTED - SIMILAR TO "CHART" FOR  a = 13 THROUGH 16

SUB chart3   'OMITTED - SIMILAR TO "CHART" FOR  a = 21 THROUGH 24

SUB chart4   'OMITTED - SIMILAR TO "CHART" FOR  a = 29 THROUGH 32

' ________________________________________________________________

SUB cprinfo  'CALCULATES CV, SV, CPI, SPI, AND TCPI

6000
a = 1
6100
IF a > 35 THEN GOTO 6200

cv(a) = bcwp(a) - acwp(a)       'cost variance
sv(a) = bcwp(a) - bcws(a)       'schedule variance
cvp(a) = cv(a) / bcwp(a)        'cost variance percentage
svp(a) = sv(a) / bcws(a)        'schedule variance percentage
'
'       Performance Indices
'
```

```
cpi(a) = bcwp(a) / acwp(a)      'Cost Performance Index
spi(a) = bcwp(a) / bcws(a)      'Schedule Performance Index
'
pc(a) = bcwp(a) / bac(a)        'Percent complete
ps(a) = acwp(a) / bac(a)        'percent spent
'
tcpi(a) = (bac(a) - bcwp(a)) / (bac(a) - acwp(a))
a = a + 1
GOTO 6100

6200

END SUB

' ____________________________________________________


SUB FaceInfo  'CONVERTS CPR DATA TO FACE INPUTS

r = 25       'face radius
mr = 10      'mouth radius
er = 7       'eye radius
ear = 3      'ear radius
pr = .75     'pupil radius
era = .5     'eye aspect ratio
eara = .8    'ear aspect ratio

a = 1
'
'        Input CPR Data
'
100
IF a > 4 GOTO 190

'
bc(a) = tcpi(a) * -.1 + 1
IF bc(a) > 1 THEN bc(a) = 1
IF bc(a) < .7 THEN bc(a) = .7
'
mc(a) = cpi(a) - 1
IF mc(a) < -1 THEN mc(a) = -1
IF mc(a) > 1 THEN mc(a) = 1
'
nl(a) = 5 + spi(a) * 5
IF nl(a) > 15 THEN nl(a) = 15
'
ef(a) = cvp(a) * 7
IF ef(a) < -7 THEN ef(a) = -7
IF ef(a) > 7 THEN ef(a) = 7
'
pf(a) = svp(a) * 10
IF pf(a) < -5 THEN pf(a) = -5
IF pf(a) > 5 THEN pf(a) = 5
a = a + 1
```

```
GOTO 100
190

END SUB


SUB Faces                          'DRAWS FACES
'
SCREEN 9
VIEW (15, 5)-(615, 125), 8, 4
WINDOW (0, 0)-(400, 100)

a = 1

'       Draw Face Outline

1000
IF a > 4 GOTO 1290

'
pi = 3.14

'
xface = (a * 100) - 50
CIRCLE (xface, 50), r, , 0, pi, 1 'top half
CIRCLE (xface, 50), r, , pi, 0, bc(a)'bottom half
'
'       Draw mouth curvature
'
IF mc(a) <= 0 GOTO 1100 ELSE GOTO 1150
'
1100 mc(a) = -mc(a)
CIRCLE (xface, 35), mr, , .2 * pi, .8 * pi, mc(a)

GOTO 1200
1150
CIRCLE (xface, 40), mr, , 1 * pi, 0 * pi, mc(a)
1200
'                              eyes
'
CIRCLE (xface - 10, 60), er, , , , era'left eye
CIRCLE (xface + 10, 60), er, , , , era'right eye
'
'       nose
'
yn(a) = 60 - nl(a)
LINE (xface, 60)-(xface + 3, yn(a))
LINE (xface + 3, yn(a))-(xface - 3, yn(a))
LINE (xface - 3, yn(a))-(xface, 60)
'
'       ears
'
CIRCLE (xface + 29, 50), ear, , , , eara
```

```
CIRCLE (xface - 29, 50), ear, , , , eara
'
'       eyebrows
'
IF ef(a) > 0 THEN GOTO 1225
yel(a) = 65 + ef(a)
LINE (xface - 5, 65)-(xface - 17, yel(a))
LINE (xface + 5, 65)-(xface + 17, yel(a))
GOTO 1250
1225
yel(a) = 65 - ef(a)
LINE (xface - 17, 65)-(xface - 5, yel(a))
LINE (xface + 17, 65)-(xface + 5, yel(a))
1250
'
'       pupils
'
x1(a) = (xface - 10) + pf(a)
x2(a) = (xface + 10) + pf(a)
CIRCLE (x1(a), 60), pr
PAINT (x1(a), 60)
CIRCLE (x2(a), 60), pr
PAINT (x2(a), 60)
a = a + 1
GOTO 1000
1290
VIEW PRINT 10 TO 24
LOCATE 11, 10
PRINT " A                    B                    C                    OVERALL"

END SUB

' ______________________________________________________________

SUB Ichart  ' LISTS TABULAR DATA FOR SAMPLE FACES

VIEW PRINT 12 TO 24
LOCATE 14, 10
PRINT "Cost Performance Information"
LOCATE 16, 10
PRINT USING "BCWS    #####     #####     #####"; bcws(33); bcws(34);
bcws(35)
LOCATE 17, 10
PRINT USING "BCWP    #####     #####     #####"; bcwp(33); bcwp(34);
bcwp(35)
LOCATE 18, 10
PRINT USING "ACWP    #####     #####     #####"; acwp(33); acwp(34);
acwp(35)
LOCATE 19, 10
PRINT USING "BAC     #####     #####     #####"; bac(33); bac(34);
bac(35)

END SUB
```

```
SUB Ifa  'OMITTED - SAME AS "Ifa" IN CPR FACES PROGRAM (APPENDIX A)

SUB Ifi  'OMITTED - SAME AS "Ifi" IN CPR FACES PROGRAM (APPENDIX A)

' ______________________________________________________

SUB intro  'INTRO SCREEN

CLS 0
VIEW PRINT 6 TO 24
LOCATE 7, 25
PRINT "Cost Performance Report Faces Demo"
LOCATE 8, 35
PRINT "by Capt Jeffrey Tkach"
LOCATE 9, 38
PRINT "AFIT/GSM"
1
LOCATE 21, 10
PRINT "Press Any Key to Continue"
hit$ = INKEY$
IF hit$ <> "" THEN GOTO 2 ELSE GOTO 1
2

CLS


END SUB

' ______________________________________________________

SUB personal  'COLLECTS BACKGROUND DATA ON PARTICIPANT

VIEW PRINT 1 TO 24
CLS
20000
INPUT "What is your current AFSC (or civilian equivalent)"; afsc$

20010
PRINT "You answered", afsc$
PRINT "Is this correct (Y/N)?"

DO
rsp$ = INKEY$
LOOP UNTIL rsp$ <> ""
IF rsp$ = "N" OR rsp$ = "n" THEN GOTO 20000

20020
CLS
INPUT "How many years of experience do you have at that AFSC"; years$

20030
```

```
PRINT "You answered", years$
PRINT "Is this correct (Y/N)?"

DO
rsp$ = INKEY$
LOOP UNTIL rsp$ <> ""
IF rsp$ = "N" OR rsp$ = "n" THEN GOTO 20020

20040
CLS
INPUT "Have you used C/SCSC before (if yes, just list how long)"; scsc$

20050
PRINT "You answered", scsc$
PRINT "Is this correct (Y/N)?"

DO
rsp$ = INKEY$
LOOP UNTIL rsp$ <> ""
IF rsp$ = "N" OR rsp$ = "n" THEN GOTO 20040

20060
CLS
INPUT "What is rank/grade"; rank$

20070
PRINT "You answered", rank$
PRINT "Is this correct (Y/N)?"

DO
rsp$ = INKEY$
LOOP UNTIL rsp$ <> ""
IF rsp$ = "N" OR rsp$ = "n" THEN GOTO 20060


WRITE #1, afsc$
WRITE #1, years$        'Write data to file
WRITE #1, scsc$
WRITE #1, rank$

END SUB

' ____________________________________________

SUB questions1             'Question Set 1

VIEW PRINT 11 TO 24


WRITE #1, "Start Time =", TIME$


'
```

```
' Question 1
'
500

LOCATE 12, 1
FOR i% = 0 TO 11
LOCATE 12 + i%, 1
PRINT SPC(70);
NEXT i%

LOCATE 13, 1

PRINT "Is the contractor BEHIND (B), AHEAD (A), or RIGHT ON (R)
schedule?"
'
510
'
DO
ansA$ = INKEY$
LOOP UNTIL ansA$ <> ""
IF ansA$ = "A" OR ansA$ = "a" OR ansA$ = "B" OR ansA$ = "b" THEN GOTO
520
IF ansA$ = "R" OR ansA$ = "r" THEN GOTO 520
PRINT "Answer  A, B, or R "
GOTO 510
'

520
                        'Echo Participant's Answer

PRINT USING "Your Answer is \    \"; ansA$

                        'Give Opportunity to Change Answer

PRINT "Do You Wish to Change Your Answer? (Y/N)"
DO
rspA$ = INKEY$
LOOP UNTIL rspA$ <> ""
IF rspA$ = "Y" OR rspA$ =  y" THEN GOTO 500

                        'Write answer to file "a:data.dat"

WRITE #1, "1 =", ansA$

525

LOCATE 12, 1
FOR i% = 0 TO 11
LOCATE 12 + i%, 1
PRINT SPC(70);
NEXT i%

'       Question 2
```

```
'
530
LOCATE 13, 1
'
PRINT "Is the contractor OVER (O), UNDER (U) or RIGHT AT (R) cost"
'
540
'
DO
ansB$ = INKEY$
LOOP UNTIL ansB$ <> ""
IF ansB$ = "o" OR ansB$ = "O" OR ansB$ = "u" OR ansB$ = "U" THEN GOTO
550
IF ansB$ = "R" OR ansB$ = "r" THEN GOTO 550
PRINT "Answer  O, U, or R "
GOTO 540
'
550
PRINT USING "Your Answer is \   \"; ansB$
'
PRINT "Do You Wish to Change Your Answer? (Y/N)"
DO
rsp$ = INKEY$
LOOP UNTIL rsp$ <> ""
IF rsp$ = "Y" OR rsp$ = "y" THEN GOTO 525
WRITE #1, "2 =", ansB$
'
555
'
LOCATE 12, 1
FOR i% = 0 TO 11
LOCATE 12 + i%, 1
PRINT SPC(70);
NEXT i%
'
'       Question 3
'
560
LOCATE 13, 1
'
PRINT "What elements are over cost:"
PRINT "(A) Element A only"
PRINT "(B) Element B only"
PRINT "(C) Element C only"
PRINT "(D) Elements A and B only"
PRINT "(E) Elements B and C only"
PRINT "(F) Elements A and C only"
PRINT "(G) Elements A, B, and C"
PRINT "(H) No elements are over cost"
'
570
'
DO
```

```
ansC$ = INKEY$
LOOP UNTIL ansC$ <> ""
IF ansC$ = "A" OR ansC$ = "a" OR ansC$ = "B" OR ansC$ = "b" THEN GOTO
580
IF ansC$ = "C" OR ansC$ = "c" OR ansC$ = "D" OR ansC$ = "d" THEN GOTO
580
IF ansC$ = "E" OR ansC$ = "e" OR ansC$ = "F" OR ansC$ = "f" THEN GOTO
580
IF ansC$ = "G" OR ansC$ = "g" OR ansC$ = "H" OR ansC$ = "h" THEN GOTO
580
'
PRINT "Answer  A, B, C, D, E, F, G or H"
GOTO 570
'
580
PRINT USING "Your Answer is \   \"; ansC$
'
PRINT "Do You Wish to Change Your Answer? (Y/N)"
DO
rsp$ = INKEY$
LOOP UNTIL rsp$ <> ""
IF rsp$ = "Y" OR rsp$ = "y" THEN GOTO 555
WRITE #1, "3 =", ansC$
'
585
'
LOCATE 12, 1
FOR i% = 0 TO 11
LOCATE 12 + i%, 1
PRINT SPC(70);
NEXT i%
'
'       Question 4
'
590
LOCATE 13, 1
'
PRINT "What elements are behind schedule:"
PRINT "(A) Element A only"
PRINT "(B) Element B only"
PRINT "(C) Element C only"
PRINT "(D) Elements A and B only"
PRINT "(E) Elements B and C only"
PRINT "(F) Elements A and C only"
PRINT "(G) Elements A, B, and C"
PRINT "(H) No elements are behind schedule"
'
600
'
DO
ansD$ = INKEY$
LOOP UNTIL ansD$ <> ""
```

```
IF ansD$ = "A" OR ansD$ = "a" OR ansD$ = "B" OR ansD$ = "b" THEN GOTO
610
IF ansD$ = "C" OR ansD$ = "c" OR ansD$ = "D" OR ansD$ = "d" THEN GOTO
610
IF ansD$ = "E" OR ansD$ = "e" OR ansD$ = "F" OR ansD$ = "f" THEN GOTO
610
IF ansD$ = "G" OR ansD$ = "g" OR ansD$ = "H" OR ansD$ = "h" THEN GOTO
610

PRINT "Answer  A, B, C, D, E, F or G"
GOTO 600
'
610
PRINT USING "Your Answer is \   \"; ansD$

PRINT "Do You Wish to Change Your Answer? (Y/N)"
DO
rsp$ = INKEY$
LOOP UNTIL rsp$ <> ""
IF rsp$ = "Y" OR rsp$ = "y" THEN GOTO 585
WRITE #1, "4 =", ansD$
WRITE #1, "stop time = ", TIME$

LOCATE 12, 1
FOR i% = 0 TO 11
LOCATE 12 + i%, 1
PRINT SPC(70);
NEXT i%

END SUB

' ------------------------------------------------------------

SUB questions2          'QUESTION SET 2

'       Question 1
'
WRITE #1, "Start Time =", TIME$

10000
VIEW PRINT 11 TO 24

LOCATE 12, 1
FOR i% = 0 TO 11
LOCATE 12 + i%, 1
PRINT SPC(70);
NEXT i%

LOCATE 13, 1

PRINT "What is the trend in schedule variance?:"
PRINT "(A) Getting Better"
PRINT "(B) Getting Worse"
```

```
PRINT "(C) Staying the Same"
PRINT "(D) No Detectable Trend"
'
10010
DO
ansI$ = INKEY$
LOOP UNTIL ansI$ <> ""
IF ansI$ = "A" OR ansI$ = "a" OR ansI$ = "B" OR ansI$ = "b" THEN GOTO
10020
IF ansI$ = "C" OR ansI$ = "c" OR ansI$ = "D" OR ansI$ = "d" THEN GOTO
10020

PRINT "Answer  A, B, C, D"
GOTO 10010
'
10020
PRINT USING "Your Answer is \   \"; ansI$

PRINT "Do You Wish to Change Your Answer? (Y/N)"
DO
rsp$ = INKEY$
LOOP UNTIL rsp$ <> ""
IF rsp$ = "Y" OR rsp$ = "y" THEN GOTO 10000
WRITE #1, "1 =", ansI$

10030
LOCATE 12, 1
FOR i% = 0 TO 11
LOCATE 12 + i%, 1
PRINT SPC(70);
NEXT i%
'
'       Question 2
'
10040
LOCATE 13, 1
'
PRINT "What is the trend in cost variance?"
PRINT "(A) Getting Better"
PRINT "(B) Getting Worse"
PRINT "(C) Staying the Same"
PRINT "(D) No Detectable Trend"
'
10050
DO
ansJ$ = INKEY$
LOOP UNTIL ansJ$ <> ""
IF ansJ$ = "A" OR ansJ$ = "a" OR ansJ$ = "B" OR ansJ$ = "b" THEN GOTO
10060
IF ansJ$ = "C" OR ansJ$ = "c" OR ansJ$ = "D" OR ansJ$ = "d" THEN GOTO
10060

PRINT "Answer  A, B, C, or D"
```

```
GOTO 10050
'
10060
PRINT USING "Your Answer is \   \"; ansJ$

PRINT "Do You Wish to Change Your Answer? (Y/N)"
DO
rsp$ = INKEY$
LOOP UNTIL rsp$ <> ""
IF rsp$ = "Y" OR rsp$ = "y" THEN GOTO 10030
WRITE #1, "2 =", ansJ$
WRITE #1, "Stop Time =", TIME$

LOCATE 12, 1
FOR i% = 0 TO 11
LOCATE 12 + i%, 1
PRINT SPC(70);
NEXT i%

END SUB

' ____________________________________________

SUB set3faceinfo  'OMITTED - SIMILAR TO "faceinfo" FOR a = 9 through 12

SUB set3faces 'OMITTED - SIMILAR TO "face" FOR a = 9 through 12

SUB set5faceinfo  'OMITTED - SIMILAR TO "faceinfo" FOR a = 17 through 20

SUB set5faces  'OMITTED - SIMILAR TO "face" FOR a = 17 through 20

SUB set7faceinfo  'OMITTED - SIMILAR TO "faceinfo" FOR a = 25 through 28

SUB set7faces 'OMITTED - SIMILAR TO "face" FOR a = 25 through 28
```

Appendix C: Experiment Data

The input data for the experiment was fabricate to represent the performance of contracts. Thirty-two data sets were prepared representing eight individual contracts. Each contract was described by a contract data group consisting of four data sets. There are two types of contract data groups. Type 1 presents three data sets representing individual elements of the contract and a fourth data set representing overall performance. This type was designed to test an individual's ability to analyze contract performance. Type 2 presents four data sets representing a specific contract period. The data for each period is cumulative (encompasses data from previous periods). This type was designed to test an individual's ability to detect trends in the data. Type 1 contract data groups are shown in Table 28. Type 2 Dat Groups are shown in Table 29.

The eight contract data groups were sorted eight different ways, so that the experiment participants would not all see the data groups in the same order. The contract data groups were copied onto floppy disks which also contained the experiment program. A total of thirty-two floppy disks were used (each ordering of contract groups appeared on four disks). The disks were randomly distributed to the participants.

TABLE 28

Contract Data Group Type 1 Data

CONTRACT DATA GROUP 1

	ELEMENT			
ELEMENT	BCWS	BCWP	ACWP	BAC
A	3000	3700	4400	5000
B	1700	1400	1100	4000
C	6000	4900	6000	7000
OVERALL	10700	10000	11500	16000

CONTRACT DATA GROUP 2

A	2300	3000	3500	6000
B	3200	3000	2800	6000
C	2000	3000	2700	6000
OVERALL	7500	9000	9000	18000

CONTRACT DATA GROUP 3

A	7500	7300	7600	8000
B	7400	7400	5700	8000
C	5500	7000	5300	8000
OVERALL	20400	21700	18600	24000

CONTRACT DATA GROUP 4

A	3000	3000	3000	5000
B	1600	1600	2400	4000
C	5000	5000	4600	7000
D	9600	9600	12000	16000

TABLE 29

CONTRACT DATA GROUP TYPE 2 DATA

CONTRACT DATA GROUP A

	ELEMENT			
PERIOD	BCWS	BCWP	ACWP	BAC
1	4900	3600	4000	20000
2	9000	7400	8000	20000
3	12500	11400	11400	20000
4	15500	15600	14600	20000

CONTRACT DATA GROUP B

1	4000	3600	3300	20000
2	8000	7400	6900	20000
3	12000	11000	10400	20000
4	16000	15000	14400	20000

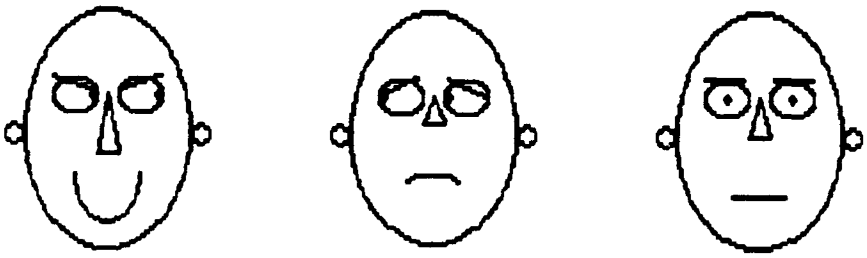
CONTRACT DATA GROUP C

1	4000	4200	4600	20000
2	8000	8400	9400	20000
3	12000	12600	14400	20000
4	16000	16800	19600	20000

CONTRACT DATA GROUP D

1	4500	3800	4200	20000
2	8000	8000	8000	20000
3	12000	12300	11000	20000
4	14500	16500	16700	20000

Appendix D: Test Scenario

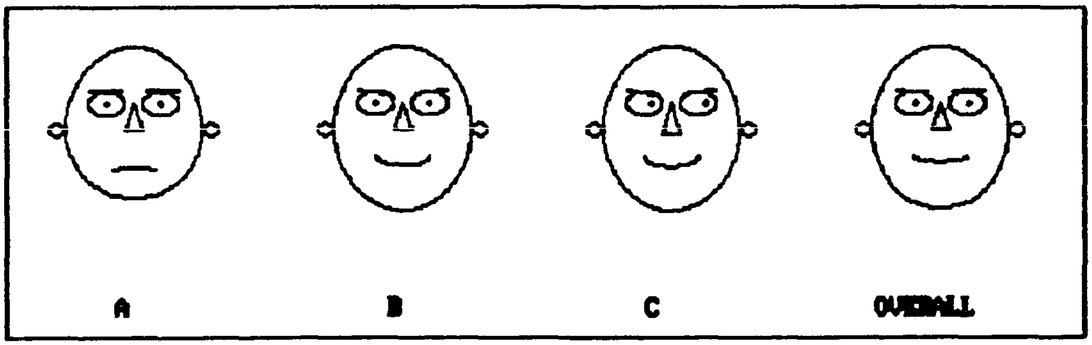


GOOD BAD NEUTRAL

Cost Performance Information

BCWS	2000	10000	4000
BCWP	4000	4000	4000
ACWP	2000	7000	4000
BAC	15000	15000	15000

Press Any Key to Continue



Is the Contractor AHEAD (A), BEHIND (B), or RIGHT ON (R) Schedule?

Is the Contractor OVER (O), UNDER (U), or RIGHT AT (R) Cost?

What Elements are OVER Cost?

A. A only
B. B only
C. C only
D. A and B only
E. A and C only
F. B and C only
G. A, B, and C
F. No elements are over cost.

What Elements are BEHIND Schedule?

A. A only
B. B only
C. C only
D. A and B only
E. A and C only
F. B and C only
G. A, B, and C
F. No elements are over cost.

ELEMENT	BCWS	BCWP	ACWP	SCHEDULE VARIANCE	COST VARIANCE
A	3000	3700	4400	700	-700
B	1700	1400	1100	-300	300
C	6000	4900	6000	-1100	-1100
TOTAL	10700	10000	11500	-700	-1500

Is the Contractor AHEAD (A), BEHIND (B), or RIGHT ON (R) Schedule?

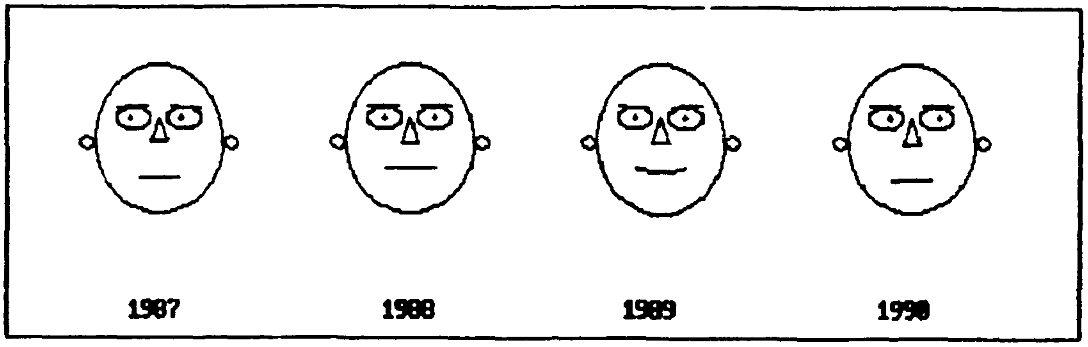
Is the Contractor OVER (O), UNDER (U), or RIGHT AT (R) Cost?

What Elements are OVER Cost?

A. A only
B. B only
C. C only
D. A and B only
E. A and C only
F. B and C only
G. A, B, and C
F. No elements are over cost.

What Elements are BEHIND Schedule?

A. A only
B. B only
C. C only
D. A and B only
E. A and C only
F. B and C only
G. A, B, and C
F. No elements are over cost.



What is the trend in Schedule Variance?

A. Getting Better
B. Getting Worse
C. Staying The Same
D. No Trend

What is the trend in Cost Variance?

A. Getting Better
B. Getting Worse
C. Staying The Same
D. No Trend

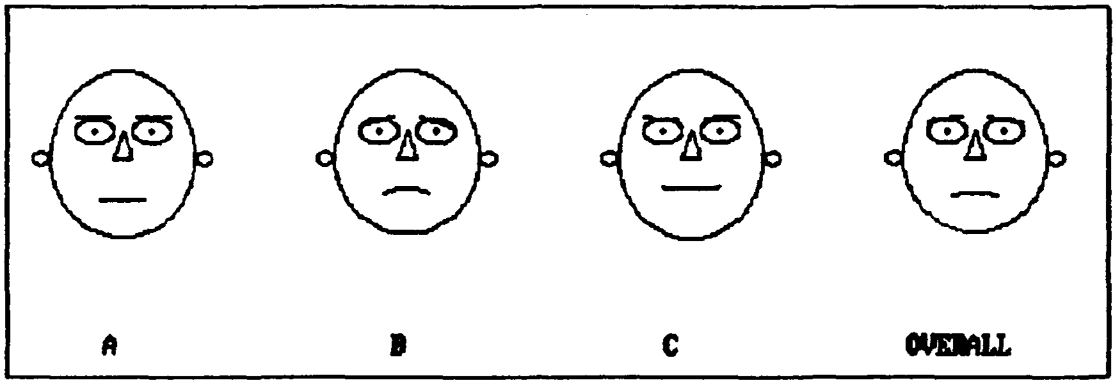
ELEMENT	BCWS	BCWP	ACWP	SCHEDULE VARIANCE	COST VARIANCE
March	4000	4200	4600	200	-400
April	8000	8400	9400	400	-1000
May	12000	12600	14400	600	-1800
June	16000	16800	19600	800	-2800

What is the trend in Schedule Variance?

A. Getting Better
B. Getting Worse
C. Staying The Same
D. No Trend

What is the trend in Cost Variance?

A. Getting Better
B. Getting Worse
C. Staying The Same
D. No Trend



Is the Contractor AHEAD (A), BEHIND (B), or RIGHT ON (R) Schedule?

Is the Contractor OVER (O), UNDER (U), or RIGHT AT (R) Cost?

What Elements are OVER Cost?

A. A only
B. B only
C. C only
D. A and B only
E. A and C only
F. B and C only
G. A, B, and C
F. No elements are over cost.

What Elements are BEHIND Schedule?

A. A only
B. B only
C. C only
D. A and B only
E. A and C only
F. B and C only
G. A, B, and C
F. No elements are over cost.

ELEMENT	BCWS	BCWP	ACWP	SCHEDULE VARIANCE	COST VARIANCE
A	2300	3000	3500	700	-500
B	3200	3000	2800	-200	200
C	2000	3000	2700	1000	300
TOTAL	7500	9000	9000	1500	0

Is the Contractor AHEAD (A), BEHIND (B), or RIGHT ON (R) Schedule?

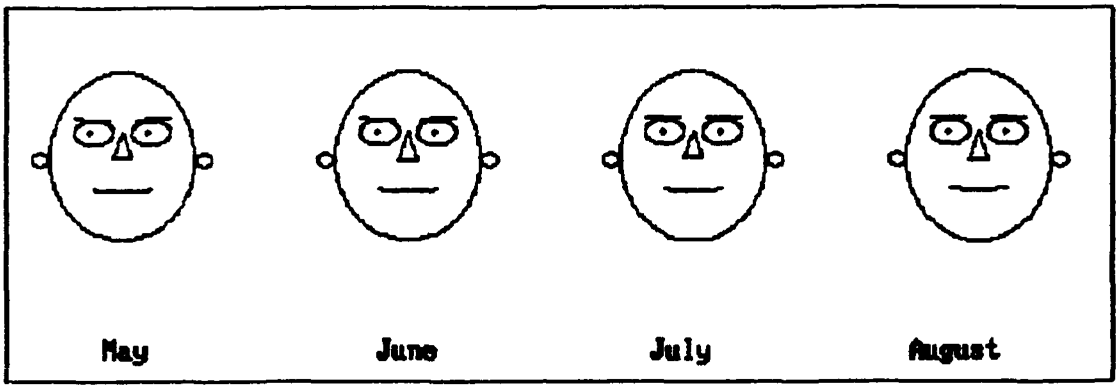
Is the Contractor OVER (O), UNDER (U), or RIGHT AT (R) Cost?

What Elements are OVER Cost?

A. A only
B. B only
C. C only
D. A and B only
E. A and C only
F. B and C only
G. A, B, and C
F. No elements are over cost.

What Elements are BEHIND Schedule?

A. A only
B. B only
C. C only
D. A and B only
E. A and C only
F. B and C only
G. A, B, and C
F. No elements are over cost.



What is the trend in Schedule Variance?

A. Getting Better
B. Getting Worse
C. Staying The Same
D. No Trend

What is the trend in Cost Variance?

A. Getting Better
B. Getting Worse
C. Staying The Same
D. No Trend

ELEMENT	BCWS	BCWP	ACWP	SCHEDULE VARIANCE	COST VARIANCE
Qtr 1	4900	3600	4000	-1300	-400
Qtr 2	9000	7400	8000	-1600	-600
Qtr 3	12500	11400	11400	-1100	0
Qtr 4	15500	15600	14600	100	1000

What is the trend in Schedule Variance?

A. Getting Better
B. Getting Worse
C. Staying The Same
D. No Trend

What is the trend in Cost Variance?

A. Getting Better
B. Getting Worse
C. Staying The Same
D. No Trend

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Vita

Captain Jeffrey Tkach [redacted]. He graduated from Palmetto High School in Miami, Florida in 1979. He attended the University of South Florida in Tampa, Florida, and graduated in December 1983 with a Bachelor of Science in Chemical Engineering. In August 1984, he entered the Air Force Officer Training School, and was commissioned as an officer of the United States Air Force upon graduation in November 1984. He was assigned to the Chemical Laser Branch, Weapons Laboratory at Kirtland AFB New Mexico, where he served as test engineer and assistant facility manager at the Chemical Laser Facility as well as project officer on several chemical laser related programs. In June 1989 he entered the School of Systems and Logistics of the Air Force Institute of Technology.

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